# IMPULSIVE NOISE FROM FORGING OPERATIONS

## REACTION OF SOME COMMUNITIES IN ONTARIO

1979



Ontario

Ministry of the Environment

The Honourable
Harry C. Parrott, D.D.S.,
Minister

Graham W. S. Scott, Q.C.,
Deputy Minister

# IMPULSIVE NOISE
# FROM
# FORGING OPERATIONS

## REACTION OF SOME COMMUNITIES IN ONTARIO

by

Baily V. Seshagiri, Ph.D,P.Eng

Noise Pollution Control Section

Baily V. Seshagiri, Ph.D,P.Eng
Senior Project Engineer

Frank Krammer, M. A.
Environmental Technician

Field Interviewers

Tunde Szathmary
Dara Heifetz
Denise Feeley
Wendy Linton

## Dedication

This report is dedicated to the people in the communities where the survey was conducted. The courtesy and friendliness with which they received the personnel involved in this programme has left a lasting impression on the author of this report.

CONTENTS

Figures

Figures | Page

Figures

Page

## Acknowledgements

Sincere thanks to Mr. John Manuel and Mr. L.G. Kende without whose help and encouragement this project could not have been completed. Several members of the staff of the Noise Pollution Control Section assisted both in field work and in many useful discussions. To all of them -- Thanks.

The interview team of Tunde Szathmary, Dara Heifetz, Denise Feeley and Wendy Linton performed an outstanding task in interviewing over 600 people and coding the results. Their work is acknowledged. The assistance of the Computer Systems staff of the Administrative Services Branch is also gratefully acknowledged.

The field interviewing team was funded through an Experience '76 grant from the Ontario Ministry of the Environment. For this assistance and for the assignment of Frank Krammer and others to this project, the support of John Manuel, Supervisor, Noise Pollution Control Section is specially acknowledged.

## SUMMARY

In order to assess the reaction of communities to impulse noise, a sociological survey was conducted in three cities in Ontario. The dominant type of industrial noise in the sites is produced by drop forging operations. A noise survey has also been conducted in the same areas in order to correlate the responses to physical measures of noise. The report describes the sites, the noise measurements, the questionnaire used and the results of the surveys.

The results fall into two parts. The first part is a visual presentation of the responses, as well as bar graphs, which qualitatively show the effect of the forging noise on the communities. The second part utilises higher levels of statistical analysis i.e , correlation and regression to relate the physical descriptors of noise to the responses.

From the results it would appear that a measure of the impulse level above ambient is best correlated with response. However, a direct measure of impulse level alone also appears to correlate reasonably well with response.

Even with the best descriptor of noise, only about 40% of the variability in the responses are explained. It would appear that socio-economic factors have an effect on the reaction to the impulse noise. Preliminary results indicate that the total household income per year and the educational level of the respondents are two factors in particular which may also help in explaining the variability of the responses. Further work to pinpoint these effects is proceeding and will be reported in detail at a later date.

## Conclusions

1. The noise from forging operations has a significant effect on neighbouring communities.

2. A new housing development in the City of Windsor appears to be far more sensitive to forge noise than the other areas surveyed. Whether this is a habituation effect or whether it is due to other socio-economic factors is not very clear.

3. Negative reaction to impulse noise appears to be greater than that to traffic noise of the same equivalent energy.

4. The best physical descriptor of noise is the impulse level above ambient, where ambient is best described by either the evening $L_{90}$ or $L_{eq}$ at a given location (which is mainly influenced by traffic noise)

5. Specific measures of impulse noise alone, using the impulse response setting of a Type 1 sound level meter, also correlates well with response.

# I. INTRODUCTION

## I (a) Objectives

The Government of Ontario passed new legislation in 1975 empowering municipalities within Ontario to enact by-laws controlling various types of noise nuisances in their communities. To assist the municipalities in this task, the Ministry of the Environment has published a document entitled "Model Municipal Noise Control By-Law" (Ref.1). This publication, prepared by the Noise Pollution Control Section of the Ministry of the Environment, sets down sound level limits for various sources of community noise. It covers such diverse sources as air conditioners, construction equipment, quarry blasting, etc. It is updated as additional technical information on noise control becomes available through research by the international acoustical community. In general, the emphasis has been on utilising, as much as possible,information on sound level limits that is available in the open literature. However, where the need has been urgent, and where such information is not readily available, the Noise Pollution Control Section has undertaken in-house projects to arrive at solutions geared to its own specific needs. Such has been the case with quarry blasting (Ref.2), noise from passing trains (Ref.3) etc.

From a review of the literature it was clear that not enough information was available on which to base recommendations limiting impulsive sounds, although it has been

established (Ref.4) that subjectively such noises tend to be more disturbing than non-impulsive sounds. A review of the complaints recorded by the Noise Pollution Control Section revealed that sizeable numbers of people are subject to varying levels of impulse noises from sources such as drop forging plants, gun clubs, etc. As a result, the Noise Pollution Control Section started a programme to investigate the reaction of Ontario communities to impulse noise.

The primary objective of the programme was to recommend suitable limits on levels of impulse noise to be included in the Model By-Law.

The secondary objective was to gather information which would be helpful for planning purposes. Questions such as the reaction of people to impulse noise vis à vis traffic noise, the dependence of the reaction to impulse noise on factors such as income, educational level, exposure time, etc., were also to be investigated.

## II ORGANIZATION OF THE SOCIOLOGICAL SURVEY

### II (a) Basic Considerations

With the objectives outlined above in mind, it was decided to proceed with following course of action:

(i) conduct a sociological survey of selected communities in Ontario dominated by impulse noise,

(ii) measure the noise climate in those communities in detail,

(iii) relate the measured noise levels to the community reaction to impulse noise.

In order to ensure that the results of the survey would be free of bias, it was decided to conduct the sociological survey on a "double blind" basis, i.e. neither the interviewers, nor the respondents were aware that it was a noise survey conducted on behalf of the Ministry of the Environment. The questionnaire was written with the above objective in mind. The hiring and training of the interviewers was also conducted under the auspices of another Ministry. This was in keeping with the recommendations of the Organization for Economic Co-operation and Development (Ref.5), an international organization which has established guidelines for social surveys

### II (b) The Sites

The primary consideration for the choice of sites was that significant numbers of people at each site should be exposed to frequent impulsive noise from an easily identifiable source. Three areas were selected, one each in the cities of Welland, Port Colborne, and Windsor (Figures 1, 2, 3). These sites were nearly ideal for the purposes of this survey. A brief description of each of the areas is given below.

The area in Welland that was surveyed is bounded by Major Street to the North, Welland St. to the South, Harold Avenue to the East and Myrtle Street to the West. East Main Street subdivides the area into two distinct neighbourhoods.

There are three large drop forging plants along Major St. General Drop Forge has about 10 hammers ranging in size from 1000 to 6000 lbs. Haun Drop Forge also has about 10 hammers ranging in size from 1000 to 3000 lbs. Canada Forgings has 8 hammers from 1600 to 10,000 lbs. To the west, Atlas Steel has an open die shop. Apart from the forging noise there is no other significantly loud industrial noise in the area. Atlas Steel is the source of a rather high, steady, background noise level which is audible immediately adjacent to their plant. However, forge noise is audible above the background hum. The plants generally operate in two shifts. Most of the forges have been in operation for the last 20 to 30 years. The noise climate to the North of East Main Street is clearly dominated by the forge noise. In the southern part of that area, forge noise is audible infrequently, depending on atmospheric conditions. East Main Street is quite heavily travelled (approximately 1400 vehicles per hour of which 5% are trucks). The side streets carry about one tenth of the above traffic. Harold Ave. has a significantly higher number of truck movements. During shift changes automobile traffic increases considerably along Harold and Myrtle Avenues. The noise climate to the South of East Main Street is general in nature consisting of people noise and some traffic noise.

In Windsor, Great Lakes Forging operate 6 hammers ranging from 3000 to 5000 lbs. This area is different from the Welland area in two respects. Firstly, the nearest residences are about 1500 ft. from the plant. Secondly, part of the area surveyed

in Windsor is in a new housing development. (Isabel Court and Isabel Place). The respondents in the new subdivision have had relatively less exposure to forge noise than the rest of the people surveyed. There is a railway line which runs just to the South of the new development with a fairly small number of train movements daily. The noise climate consists of forge noise and people noise. There is relatively little traffic in the area.

In Port Colborne, Port Colborne Drop Forge operate 4 hammers ranging from 1500 to 5000 lb. The area surveyed is bounded by Killaly to the North, and James to the West. There are railway tracks to the south and open field to the East of the area. The noise climate consists of forge noise, train noise (mostly shunting) and people noise. There is very little traffic in the area. Killaly Street has a speed limit of 40 mph and carries roughly 400 vehicles/ hour during day time.

II. (c) The Questionnaire

The questionnaire was constructed taking into account the "double blind" nature of the survey. Consequently it was necessary to camouflage the questions related to noise. Several types of questionnaires were written, including one to be administered under the guise of a household appliance noise survey. The final version was entitled Neighbourhood Factors Questionnaire (Appendix A).

The questionnaire consisted of four sections: 1) Neighbourhood Factors; 2) Activities; 3) Personal Data; 4) Observational Data. There were a total of about 66 questions of which only 19 were directly related to noise. Several other questionnaires (Refs. 6, 7,8,9) were studied. The use of elaborate scaling for rating noise was discarded and it was decided to keep the questions simple and brief. The recommended practice (Ref. 5) of getting voluntary responses in the initial part of the questionnaire and eliciting specific responses at a later stage was adhered to.

It was decided to get responses related to general disturbances, indoor or outdoor activity disturbance and sleep disturbance. None of the questions were directly addressed to forge noise. Noise in general was categorized into 6 groups: 1) People 2) Traffic 3) Railroad 4) Industry 5) Aircraft 6) Other. In eliciting responses, noise was given as an alternate of one among several other factors. Some of the questions relating to noise are discussed below in detail.

Question 2

This question in two parts was considered one of the key indicators of reaction to noise. It calls for a voluntary response without any prompting on the part of the interviewer. Response to 2(b) has been taken to represent a strong negative reaction.

Question 8

8(a) attempts to establish whether the respondent considers that it is generally "Quiet" or "Noisy" in his neighbourhood. It is recognized that the words "Quiet" or "Noisy" are open to more than one interpretation. But this seemed unavoidable.

Questions 8 c, d, e and f attempted to establish at what time of day the noise was disturbing, what the source of the disturbing noise was, rating of the disturbance (slightly, moderately or considerably disturbed) and finally whether the respondent had to sometimes close windows as a result of the noise. A negative response to these questions has been taken as a general negative reaction, not as strong as that evoked in question 2(b). These are considered as elicited responses.

Question 14

This question has also been considered to evoke a voluntary response. Because of the difficulty in conceptualizing the word "feature" the responses were not expected to be as significant as those to 2 (b).

Question 16 and 17

Question 16 (a) and 17 (a) merely serve to define indoor and outdoor activities. It was expected that respondents would respond positively to most of the options in these questions. 16 (c) and 17 (b) attempt to elicit whether "noise outside" disturbs them in either indoor or outdoor activities respectively. Only if it is established that "noise outside" does disturb the activities are questions 16 (d) and 17 (c) asked, to pinpoint the source of the disturbing noise. These are considered elicited responses.

Question 18

This question follows a pattern similar to 16 and 17. Only after establishing that the respondent is "kept from falling asleep" by noise outside, is the attempt made to establish the noise source.

Personal Data

Because of the specific and limited objectives of the program it was decided not to seek very detailed personal information. Basic information such as approximate age, income, education, etc., was obtained.

Observational Data

The interviewers were required to note down certain information which they could easily observe, such as the type of dwelling, presence of air conditioners, command of English, etc. They were also asked to record the location of the interview, i.e. outdoors or indoors, and whether any outside noise was audible during the interview.

II. (d) Survey Logistics

Four university students were employed to conduct the interviews. They were given adequate time to familiarize themselves with the questionnaire. They also conducted some trial interviews in Toronto. Their comments and suggestions are in fact reflected in the final version of the questionnaire.

The interviews in Welland and Port Colborne were conducted from 14 to 24 June, 1976. About 561 persons in 360 households were contacted in Welland, of whom nearly 80% consented to be interviewed. In Port Colborne about 67 persons in 49 households were contacted, and nearly 91% took part in the survey. These statistics are given in Table 1. Each interview lasted approximately 30 minutes.

The interviews in Windsor were conducted on August 20 and 21. Because of time delay between the interviews in Welland and those in Windsor, the interviewers were aware of the nature of the project in Windsor. However the respondents in Windsor were kept unaware that it was a noise survey. Nearly 500 interviews had been conducted before proceeding to Windsor. It was therefore assumed that the interviewing patterns were established well enough as not to be significantly changed by the knowledge of the nature of the project.

About 140 persons from 134 households were contacted in Windsor, of whom nearly 71% agreed to be interviewed.

The excellent response rate is a tribute to the interviewers, as well as the people in the communities surveyed. In almost every instance the interviewers reported that they were very well received by the householder.

# III. MEASUREMENT OF THE NOISE CLIMATE

## III (a) Subjective Description of the Noise Climate

A brief description of the general noise climate in the survey areas has already been presented in Section II (b). The extent of audibility of forge noise within the communities surveyed will be described below.

Fig. 4 is a visual presentation of observational data of forge noise and traffic noise in the Welland area. Forge noise is loudest along Harold Avenue and White Avenue and generally reduces in intensity as one moves West and South. Main Street acts as a dividing line between the North and South sub-divisions. Forge noise becomes less frequently audible as one goes south of Main Street. It becomes more and more dependent on wind direction. Traffic noise on the other hand is spread uniformly throughout the area with the exception of Harold Avenue. Large trucks tended to use Harold Avenue to transport material to and from the forge plants. A noticeably quiet street was Scholfield Avenue North. This will be discussed in Section III (d), Level Adjustment.

In Port Colborne, because of the distance of the forge plant from the community (approx. 1500 fet.), the level of forge noise audible varied, depending on wind conditions. In general, it was almost uniformly distributed through the community. It could be described as moderately high.

In Windsor, at the time the interviews were being conducted, the forge plant had shut down for modifications and subjective assessment of forge noise levels was not possible. This is also discussed in Section III (d).

III (b) Equipment and Procedure Used to Quantify the Noise Climate

The noise measurements were taken after the interviews had been completed. The bulk of the measurements consisted of analogue recordings of approximately half an hour duration. In Welland such recordings were taken at 33 locations (Fig. 5 ), in Port Colborne at 5 locations. In Windsor a different procedure had to be used which is described in Section III d.

The analogue recordings were made using a Nagra IV tape recorder and a Bruel & Kjaer 2209 Impulse Sound level meter with a B & K 1/2 inch microphone and windscreen. The microphone was located roughly 4 ft. above the ground on the sidewalks, roughly 10 to 20 feet from the residences. In addition to the overload indicator (lights) on the SLM, another overload indicating device (designed in the NPCS) which assures that the tape recorder is not overloaded, was also used. The recordings were made using high quality tapes running at 7 1/2 inches per second.

The recordings were made only when the forge noise was audible. At some locations several visits had to be made to ensure this. A record of the total amount of time spent at a given location was kept in order to get a rough idea of the frequency of audibility of the forge noise.

In addition to the analogue recordings, several visits were made and spot readings were taken. All the measurements were taken under summer and fall daytime conditions.

In addition to the above measurements of forge noise, 24 hour digital monitoring was carried out at 4 locations in Welland, one in Port Colborne. The monitors (Digital Acoustics 603A) were located sufficiently far from the forge plants that they essentially

measured the ambient noise (from traffic and people) not including forge noise. These monitors set at a sampling rate of 1 sample a second provided measurements of $L_{eq}$ and percentile levels of the background noise for different time durations up to 24 hours.

## III (c) Data Reduction

The data reduction from the analogue recordings were carried out in the NPCS laboratory. The tapes were played back and the output was fed into a specially designed network with gain control, "A" weighting, squaring and averaging circuits. The averaging times could be set for either fast, slow or impulse response. ($L_{eq}$ output was also available.) This was displayed on a UV chart recorder. The "A" weighted pressure signal was also fed into a B & K 2305 level recorder and a B & K 4420 Statistical Distribution analyser. The "A" weighted, squared and averaged signal was fed into a NPCS designed dual channel dosimeter. As a result, it was possible to obtain the following measurements from the analogue signal (termed spot levels):

1. Chart recordings of level-time histories for fast, slow and impulse response.
2. Percentile levels such as $L_{90}$, $L_{50}$, $L_{10}$.
3. Equivalent sound level, $L_{eq}$.

From the chart recordings, impulse levels of each individual impulse could be read. From these readings the distribution of impulse levels at a given location was obtained. From the distribution, the level exceeded by 10% of the impulses (IMP10) was obtained. The mean value and the standard deviation were calculated. In addition, a weighted mean value (Impulse Weighted Mean Level - IMPWM) was calculated. This is done simply by calculating the mean of the

anti-log of one-tenth the impulse levels, and taking 10 times the log of this mean. This tends to emphasize the higher levels.

Finally, with the use of 3 impulse SLM's, sets of simultaneous measurements were taken along Harold and White Avenues to cross-check the previous analogue measurements.

## III (d) Data Adjustment

From the analogue measurements and the spot readings, values of each of the noise descriptors were attached to each measurement location. There were two problem areas.

In Windsor, at the time the interviews were conducted, Great Lakes had shut down their plant pending expansion and construction of a new building. By the time the noise measurements were taken, they had completed construction, with the result that the new building which houses the forges substantially attenuated the noise being radiated into the community. However, the residents in the area, at the time they were interviewed, had no knowledge that in fact Great Lakes was planning to abate their noise emissions. It was assumed that their responses reflected reaction to noise levels which existed prior to the new construction. In order to estimate what those levels were, the measurements carried out by Z . Reif (Ref. 10 ) were used. These measurements, taken in 1974, were quite detailed and in fact some of the locations were in the area of the present survey - along Mathew Brady Boulevard. However, along Isabel Court and Isabel Place, measurements were not available. As a result, Reif's measurements were used to estimate the level along these streets based on the distance from the forge plant.

Digital monitoring to establish percentiles and $L_{eq}$ was also carried out at 3 locations (Mathew Brady, Belle Isle View and Isabel Court).

In Welland a somewhat similar problem was encountered on Scholfield Avenue. Haun forge which normally was the dominant source radiating along Scholfield Ave. had started construction of their administration building immediately in front of their forge plant. This building which was being constructed at the time of the interviews, had been finished when measurements were taken. Consequently, levels along Scholfield were estimated by interpolation of measured values along both the North-South and the East-West directions.

To the South of Main Street, as mentioned earlier, audibility of forge noise depends to a great extent on atmoshpheric conditions. Levels to the South of Main Street were obtained from spot measurements as well as extrapolation of measured values of decay rates obtained to the North of Main St.

The next step was to assign noise levels to each respondent of the survey. Port Colborne was treated as one homogeneous group and all the respondents were then assigned the same set of values based on the average measured levels. In the area to the North of Main St. in Welland, a different procedure was used. This area was too large to be treated as a homogeneous entity. Rather, the measured level at a given location was assigned to the houses adjacent to the measurement location. As one moved farther south from the plants, the number of houses between measurement locations increased. In this case, the assignment of levels reflected the fact that the noise levels decreased logarithmically with distance from the forge plants.

Fig. 6 shows an example of the distribution of the final adjusted levels in Welland.

## IV VISUAL PRESENTATION AND TABULATION OF RESPONSES

### IV (a) Introduction

The results obtained from the survey and the analysis of these results may be presented on different levels of complexity, the simplest being visual presentation. This is useful to check the geographical spread of responses and to spot any obvious trends. However, no quantitative information can be obtained. It is also time consuming. Consequently, only a limited number of responses are shown. Responses from Port Colborne and Windsor have not been displayed. At these two sites relatively smaller numbers of interviews were completed. Because of the layout of the site in Welland, it is also easier to interpret the data visually.

Figures 7 to 15 show some of the responses marked on the site map. In general, on all of the maps, each house in the area has been marked with the associated house number. Each of the much darker outlines (in green) on the rectangles represents a completed interview. In a number of instances, two interviews were completed in a single household. The responses themselves are coded and marked for each respondent.

These displays are especially useful for comparing the Northern and Southern parts of the site. It will be seen that the two areas are similar in many respects in terms of distribution of males/females interviewed, income levels, educational levels etc. However, the impact of the forging plants is almost negligible in the southern part of the site. This is reflected very clearly in the responses.

IV (b) Visual Presentation of Some Responses (Welland Site only)

(i) Distribution of Males/Females

Fig. 7 is a display of the distribution of males and females interviewed in Welland. It is clear from this presentation that there is no significant concentration of either males or females interviewed in Welland. This was generally true of the other two sites as well.

(ii) Distribution of Income/Education

The distributions of income and educational level of the respondents in Welland are shown in Figs. 8a,b. The majority of the households are in the 10 to 20,000 dollars/ year bracket. A significant number of respondents reported incomes below 10,000 dollars/year. The distribution of educational level among the respondents is somewhat more difficult to interpret from this display. There are significant numbers of respondents in each of the three categories - elementary, secondary and post-secondary. Post-secondary includes respondents who may have attended community college, university or other types of occupational training. From Figs. 8a,b, no conclusions can be drawn indicating a concentration of lower income, lower educational level respondents close to the forge plants.

(iii) Voluntary Response - Dislike Proximity to Industry

Fig. 9 is a display of the voluntary response to Question 2(b). These are the respondents who expressed that one of the factors that they disliked about their neighbourhood was that it was close to industry. This feeling appears to extend up to about 1000 ft. from the plants. Whether the presence of Main Street with its associated vehicular noise acts

to offset the impact of industry as one moves into the southern part of this site is an interesting question about which one can only speculate.

(iv) Voluntary and Elicited Responses - Bothered By Smoke and/or Dust From Industry

Fig. 10 is a display of two types of responses - voluntary and elicited, to questions relating to smoke or dust from industry. The voluntary response is to Question 2(b) and the elicited response is to Question 12. In general, respondents who expressed voluntarily that they disliked their neighbourhood due to smoke or dust from industry also responded to Q. 12, expressing that they were bothered by smoke or dust from industry. On the other hand, the elicited responses outnumber the voluntary ones.

(v) Voluntary and Elicited Response - Dislike Neighbourhood Because of Noise (any type) Elicited Noisy Neighbourhood

Fig. 11 is a display of voluntary and elicited responses to questions relating to noise in general in the neighbourhood. No attempt has been made to differentiate between types of noise. The voluntary response represents respondents who expressed dislike of their neighbourhood due to any type of noise (Question 2b ). The elicited response is from 8(a) to ascertain whether it is generally "quiet" in the neighbourhood. Respondents who expressed voluntarily that they disliked their neighbourhood because they considered it too noisy, also responded to question 8(a), that they considered their neighbourhood not quiet. This again indicates an internal self-consistency in the responses. As may be expected, there were more negative elicited responses than voluntary responses.

(vi) Voluntary and Elicited Responses - Dislike/Disturbed By Noise from Industry

Fig. 12 illustrates voluntary and elicited responses to questions related to noise from industry. Voluntary response to question 2 b is from respondents who specifically expressed that they disliked their neighbourhood because of industry noise. Elicited response includes negative responses to question 8 (d), 16 (d), 17 (c), 18(d). Comparison with Fig. 11 indicates that, of the respondents in South Welland who expressed that their neighbourhood was not "quiet", the vast majority of them did not indicate that they were disturbed by industry noise, either voluntarily or through elicited responses. The responses from North Welland do show that a considerable number of them attribute the noisiness in their neighbourhood to industry.

(vii) Voluntary and Elicited Responses - Dislike/Disturbed By Traffic Noise

Fig. 13 is a display of responses to questions related to traffic noise. It is analogous to the responses concerning industry noise discussed in item (vi) above. It is seen that in South Welland there are significantly more respondents who expressed that they were disturbed by traffic noise in their neighbourhood.

(viii) Rating of Disturbance from Industry Noise

Fig. 14 is a display of responses to Question 8(e). It is an attempt to rate the disturbance due to industry noise i.e. whether the respondents were Slightly, Moderately or Considerably disturbed by industry noise. From the display it is not clear whether a particular trend exists.

(ix) <u>Activities, Sleep Disturbed By Industry Noise</u>

Fig. 15 is a display of responses to Questions 16 (d), 17 (c) and 18 (d). These are respectively the respondents who expressed that their (1) indoor activities, (2) outdoor activities, or (3) sleep was disturbed by industry noise.

## IV (c) Comparison of Sites Based on Distributions of Non-Acoustical Variables

### (i) Introduction

In any field experiment where one attempts to correlate responses to a sociological survey with measurements of physical variables, a degree of uncertainty is bound to be present. In other words, one will never be able to completely account for the variability in responses by physical measurements alone. This problem becomes more acute when the sites chosen differ significantly from each other. Some of the more common parameters which could affect responses are:

1) Number of years of residence
2) Age of respondents
3) Educational level
4) Income
5) Occupation
6) Sex
7) Amount of time spent at home

It is useful to compare how these parameters are distributed within each site. For purposes of comparison distributions are shown as bar graphs for:

1) South Welland
2) North Welland
3) Port Colborne
4) Windsor
5) All sites combined

### (ii) Distribution of Number of Years of Residence

Fig. 16 shows the above distribution. It should be noted that the shape of the distribution is affected by the grouping of the variable. The distribution for Port Colborne is quite narrow and has a pronounced peak for the group 11 to 20 years.

This is a reflection of the fact that this sub-division was developed approximately 15 years back and has been substantially stable. The distribution for Windsor has two pronounced peaks, one for the group 0.5 to 1.4 years and the second for 11 to 20 years. This corresponds to distinct areas within the Windsor site. The area encompassing Mathew Brady Boulevard, and Belle Isle view are older neighbourhoods while Isabel Court and Isabel Place are new sub-divisions. Differences between the distributions for North & South Welland are not significant and they are less peaky.

The overall distribution shows a mild peak for the group 11 to 20 years.

(iii) Distribution of Age of Respondents

This is shown in Fig. 17. Respondents have been grouped into five categories. About 15 to 20 percent of the respondents in each site are between 18 to 25 years. The majority of the respondents in Port Colborne are in the age range 36-45 years. In Windsor the peak is in the group 26-35 years. North and South Welland have very similar distributions. Windsor and Port Colborne have substantially lower number of respondents over 60 years of age.

(iv) Distribution of Educational Level

Fig. 18 shows the above distribution. Windsor has significantly higher numbers of respondents who have had post-secondary education. More than twice as many respondents have attended community college in North Welland than in South Welland.

(v) Distribution of Income Level

Total yearly household income in 4 categories: 1) under 10,000; 2) 10-20,000; 3) 20-30,000; 4) over 30,000, is shown in Fig. 19. Respondents in Windsor appear to be more affluent than in the other sites. There are fewer of them earning less than $10,000/year.

(vi) Distribution of Types of Occupation

The above distribution for the following categories is shown in Fig. 20:

1) unemployed/retired 2) Housewife 3) unskilled
4) skilled 5) professional/managerial 6) other

There are more professionals and people with managerial jobs among the respondents in Windsor than in the other sites. Port Colborne appears to have a surprisingly large number of unskilled people. The percentage of housewives in each of the sites is roughly the same (about 35 to 40%).

(vii) Distribution of Sex of Respondents

The percentage of males and females among the respondents at each site is shown in Fig. 21. In general the percentages are similar at all the sites, 35 to 40% males and 60 to 65% females. Special efforts were made to ensure roughly equal numbers of males and females were interviewed. This was done by conducting interviews during evening and night time hours when more males may be expected to be available for interviews.

(viii) Distribution of the Amount of Time Spent at Home by Respondents During Weekday Daytime Hours

This distribution is shown in Fig. 22. The variation between sites is very small. Roughly 5% of the respondents spend

less than 1 hour a day at home between 7 a.m. & 7 p.m. Nearly 50% spend over 8 hours a day at home between the same hours. This would correspond with the fact that nearly 35 to 40% of the respondents were housewives and about 10% were either unemployed or retired.

IV (d) Responses to Specific Questions Not Related to Environmental Concerns

(i) Introduction

As discussed in II (c), a number of questions had been included which were not related to environmental problems. These were questions on neighbourhood factors in general. Responses to such questions could be of use to urban planners. The responses could also be used as a measure of the priority of environmental concerns. Responses to Questions 3, 4, 5, 6, 7, 10, 11 and 13 are discussed below.

(ii) Location of Shopping Facilities

This question in two parts first attempts to establish whether the respondent feels that he or she is close or far from shopping facilities, and then requires the respondent to say whether he or she likes the location of the shopping faciltities vis à vis his or her neighbourhood.

Fig. 23 is a bar graph of the % of respondents who do not "like" the location of shopping facilities. The response from Port Colborne reflect the fact that there are no shopping facilities close to that development.

(iii) Location of Place of Work

This question is akin to question 3, and is related to the respondents place of work. The bar graph of the percent of respondents who do not "like" the location of their place of work is also shown in Fig. 23. The negative reaction is less than 10% at any of the sites.

(iv) Open Space in Neighbourhood

The percent of people who expressed that there was not enough open space in their neighbourhood is shown as a bar graph in Fig. 24. The interpretation of the words "open space"

may be open to question and the answers may partly reflect the ambiguity.

(v) Recreational Facilities in Neighbourhood

Question 6 in three parts attempts to elicit answers to the following questions:

1) Whether the respondent feels that there are enough recreational facilities in his/her neighbourhood.
2) If not, what type of additional recreational facilities he/she would like provided.
3) Whether he/she is prepared to pay additional taxes to get more recreational facilities.

Fig. 25 shows bar graphs of responses to (1) & (3) above. Roughly 45% of the respondents felt that recreational facilities were lacking in their neighbourhood. About 20% expressed that they were willing to pay additional taxes to obtain more recreational facilities.

(vi) Public Transportation

Question 7 attempts to assess the respondents opinion of the public transportation in their area. The percent of respondents who felt that public transportation is "poor" in their area is shown as a bar graph in Fig. 26. The respondents in Windsor and Port Colborne appear to be the most concerned.

(vii) Neighbours

Question 10 attempts to elicit the respondents opinion of his or her neighbours. The percent of respondents who expressed that their neighbours were "unfriendly" is shown as a bar graph in Fig. 26. The negative responses were almost negligible.

(viii) City Services

Question 11 in three parts attempts to elicit the respondents opinion of city services such as garbage pick up, street cleaning, snow removal etc., in his/her neighbourbood. The percent of respondents who expressed that city services were "poor" in their neighbourhood is shown as a bar graph in Fig. 27. The respondents in Port Colborne were the most critical.

(ix) Neighbourhood Safety

Question 13 in two parts attempts to elicit the respondent's opinion as to the safety of his/her neighbourhood. As seen in the bar graph of Fig. 27, only a negligible number of respondents felt that their neighbourhood was "unsafe".

## IV (e) Responses Related to Noise

(Welland Site Only)

### (i) Introduction

It is clear from the previous sections that of the three areas surveyed, Welland with nearly 450 respondents presents a homogeneous structure with a minimum of variability of such parameters as years of residence, age of respondents, income level,etc. Because of this, it is easier to interpret the results from the Welland area. The division of North and South Welland due to the presence of a fairly well travelled road such as Main Street also affords one a chance to view South Welland as a control area where the effect of industry is negligible. Hence it is easier to compare the reactions of the two groups of respondents, similar in all respects except that one is significantly affected by industry noise and the other is not. Consequently, the responses from Welland alone are discussed below. In all of these discussions, comparisons are made between reaction to traffic noise and industry noise. As mentioned earlier, industry noise is almost exclusively the impulse noise from the forging operations along Major St. It must also be noted that the traffic noise is due mostly to local traffic.

### (ii) Neighbourhood Factors - Likes and Dislikes

From the voluntary responses to questions 2(a) and (b) one can compare the general attitude of the respondents to their neighbourhoods. Each respondent was expected to itemize a maximum of three "things" he/she liked or disliked about the neighbourhood. A similar estimate may be made using the elicited responses from question 3b , 4b, 5, 6a, 7, 8a, 9a, 10, 11a, 12a, 13a. Table 2 shows the number of

voluntary and elicited responses per respondent in North and South Welland. The residents in South Welland appear to rate their neighbourhood slightly better than their counterparts in North Welland. This Table also provides another interesting check on the internal self-consistancy of the responses. The ratio of the number of elicited likes per respondent to the voluntary likes is the same for both sections (6.92/2.04 = 3.39, 6.19/1.85 = 3.34). The corresponding ratios for dislikes are also equal to each other (1.74/.98 = 1.775, 2.65/1.54 = 1.7). This could be interpreted to mean that even the elicited responses are relatively free of bias either due to the wording of the questions or due to interviewer attitudes.

(iii) Neighbourhood Quiet/Noisy

Fig. 28 is a bar graph of voluntary responses from question 2 (a), (b) and elicited responses from question 8 (a). It is seen that 30% of respondents in S. Welland volunteered that they liked their neighbourhood because it was quiet whereas only 18% of the residents in N. Welland had the same reaction. This is also revealed in the elicited "quiet" response; nearly 58% in S. Welland to 35% in the North. About 15% in the South volunteered that they disliked the noise in their neighbourhood, whereas 35% had the same opinion in the North.

(iv) Reaction to Industry/Traffic in General

The bar graph in Fig. 29 shows the reaction to industry and traffic in general in the two areas from the volunteered responses to question 2 (b). Less than 5% of respondents in S. Welland expressed dislike of their neighbourhood because of the presence of industry whereas it was over 45% in N. Welland.

The negative response to traffic in the neighbourhood is similar in both areas. About 25 to 30% expressed voluntary dislike of their neighbourhood because of traffic.

(v) Reaction to Industry/Traffic Noise

The bar graphs in Fig. 29 show the reaction to industry and traffic noise. It is seen that nearly 25% of the respondents in North Welland expressed voluntary dislike of their neighbourhood due to industry noise. Whereas less than 5% had the same opinion in S. Welland. For traffic noise, in both neighbourhoods voluntary expression of dislike was negligible.

The elicited response from question 8 is similar for industry noise, about 5% in S. Welland and 30% in N. Welland had negative reactions. The elicited response to traffic noise shows a large increase in negative reaction in both neighbourhoods - approximately 35%. It appears that though the respondents express a strong negative (voluntary) reaction to traffic in general, noise is not of primary concern, whereas in the case of industry, noise is of primary concern.

(vi) Disturbed Indoors by Industry/Traffic Noise

The responses from 16 (d) are shown in the form of a bar graph in Fig. 30. Nearly 30% of the respondents in N. Welland expressed that some of their indoor activities (such as reading, listening to music, watching TV. etc) were disturbed by industry noise. Less than 5% had a similar reaction in S. Welland. However, about 28% of the respondents in both areas expressed that their indoor activities were disturbed by traffic noise.

(vii) Disturbed Outdoors by Industry/ Traffic Noise

The response to 17 (c) is shown in Fig. 30. Fewer respondents reported being disturbed outdoors by either traffic or industry noise although the pattern was similar to the response to 16 (d). About 20% in the North and 5% in the South expressed outdoor activity disturbed by industry noise and 20% by traffic noise.

(viii) Sleep Disturbance by Industry/Traffic Noise

The response to 18(d) is shown in Fig. 30. About 17% in the North and 1% in the South expressed that their sleep was disturbed due to industry noise. For traffic noise it was 10 % and 3% respectively.

(ix) Rating of Industry /Traffic Noise

Responses to 8 (d) are shown in Fig. 31 as a series of bar graphs. The results are not instructive. Marginally greater percentage of respondents appear to be considerably disturbed by industry noise. Roughly the same percentage (10%) are also considerably disturbed by traffic noise.

IV (f) Responses Related to Noise - All Sites

(i) Introduction

In this section, responses from all the sites to questions related to noise are displayed in the form of bar graphs. As shown in IV (e) South Welland is only marginally exposed to forge noise. In this section, for purposes of comparison, it is treated as a control group. The responses from the rest of the sites have been lumped. It is recognized that the communities surveyed in Port Colborne and Windsor are not as similar to South Welland as North Welland is, and in that sense, to use it as a control group raises questions. However, in terms of the acoustical environment, the groups are similar. Apart from forge noise, all of the communities are exposed to local traffic noise of comparable magnitudes. The train noise in Port Colborne and in the new development in Windsor appear to have only marginal impact. Elicited responses to questions 8, 16, 17, and 18 are discussed below.

(ii) Neighbourhood Quiet/Noisy/Neither

The responses to 8 (a) are shown in Fig. 32. 58% of respondents in S. Welland consider their neighbourhood to be quiet and about 24% as noisy. 18% considered it sometimes noisy. 44% in the rest of the sites considered their neighbourhood quiet and 35% as noisy and 21% considered it sometimes noisy.

(iii) Disturbed by Noise

The responses to 8 (b) are shown in Fig. 33. Of the 42% in S. Welland who expressed that their neighbourhood was not quiet, 60% were disturbed by the noise outside. In the rest of the sites, of the 56% who expressed that their neighbourhood was not quiet, 74% expressed that they were disturbed by the noise outside. As a percentage of the total number of

respondents, 25% were disturbed in S. Welland and 41% in the rest of the sites by the noise in their neighbourhoods.

(iv) Disturbed by Industry/Traffic Noise

The responses to question 8 (d) are shown in Fig. 34. Of the 25% in S. Welland who were disturbed by noise in their neighbourhood, all of them expressed that they were disturbed by traffic noise and 5% (of the total number of respondents) also expressed that they were disturbed by industry noise. In the rest of the sites, of the 41% who were disturbed, 32% were disturbed by industry and 20% by traffic. It is seen that roughly 20 to 25% of all the respondents generally were disturbed by traffic in their neighbourhoods. In addition roughly the same percent of people were also disturbed by industry noise, the disturbance due to traffic noise being spread uniformly in all the sites whereas that due to industry noise is primarily in N. Welland, Port Colborne and Windsor.

Fig. 34 shows the rating of the disturbance as expressed by the respondents. In general, of the respondents in the combined group who expressed that they were disturbed by industry noise, more of them said they were considerably disturbed than either slightly or moderately. The response was similar for traffic noise as well. In S. Welland, the numbers were about evenly distributed for the traffic noise rating. One possible explanation for the higher response of "considerably" disturbed by traffic noise in the combined group may be the larger percentage of trucks which go through some of the roads in N. Welland.

(v) Activities Distrubed by Industry/Traffic Noise

Responses to questions 16(b), (c), (d), 17 (b), (c) are displayed in Fig. 35, for S. Welland and the rest of the sites combined.

Nearly 50% of the respondents indicated that their indoor activities (such as reading, watching T.V., etc.) were disturbed by outside noise in the combined group and about 30% in S. Welland had a similar reaction. Of these, in the combined group, about 30% said the source of disturbance was industry noise and about 10% said traffic noise. In S. Welland the percentages were 5% and 23% respectively. 33% of respondents in the combined group expressed that their outdoor activities, (such as gardening, relaxing outside, etc) were disturbed by noise, and the breakdown for industry and traffic noise was 20% and 8% respectively. For S. Welland the percentage were 22%, 4% and 14% respectively.

(vi) Sleep Disturbance

The responses to questions18(c) , (d) and (e) are shown in Fig.36. 40% of the respondents in S. Welland and 49% in the rest of the sites expressed that they were "kept from falling asleep" due to any reason, such as people noise, any other noise or personal matters. About 7% in S. Welland and 20% in the combined group attributed this to noise. Out of this, less than 1% in S. Welland and 13% in the combined group specified the source as industry. For traffic noise it was 5% & 7% respectively.

4% in S. Welland and 13% in the rest of the sites expressed that because of sleep disturbance from outside noise, they had to close their windows. The cross tabulation for industry noise resulted in less than 1% for S. Welland

and 10% for the rest. For traffic noise, it was 3% and 5% respectively.

(vii) Disturbed in General by Noise from Industry/Traffic/Other

The responses to all the questions related to noise have been combined to give a general negative reaction to noise. A respondent is considered to be disturbed by noise if such a negative response has been obtained either voluntarily (2b), or, through an elicited question (8d, 16d, 17c, or 18d). These are denoted by NSANY 1, NSANY 2 or NSANY 3 for disturbance by industry, traffic or other noises respectively. Other noises comprise train noise and people noise. Fig. 37 is a display of these combined responses for S. Welland and the rest of the sites. Out of 123 respondents in S. Welland, about 7% indicated that they were disturbed in general by industry noise i.e. about 9 or 10 respondents. In the rest of the sites, out of 484 respondents nearly 45% i.e. 218 people, expressed that they were disturbed by industry noise. Approximately 45% in S. Welland and 35% in the rest of the sites expressed that they were disturbed in general by traffic noise. 13% in S. Welland and 20% in the rest of the sites expressed that they were disturbed by noise from other sources, predominantly people noise and train noise. The rather high reaction to traffic noise in S. Welland may be partly because East Main St. has been included in that group. It is a heavily travelled road. Of the 18 respondents who live on that street, 13 expressed that they were disturbed by traffic noise. If these were excluded from the S. Welland group, the % disturbed would be 40, which is comparable to the 35% in the rest of the sites.

## IV (g) Cross-Tabulation of Responses Related To Noise With Non-Acoustical Variables

### (i) Introduction

As noted in Section IV(c), a number of non-acoustical parameters are expected to affect the subjective response to noise. In order to make a preliminary assessment of such effects, the general response to noise (NSANY1 and NSANY2) has been cross-tabulated with some of these parameters. The noise response has been grouped into S. Welland and the rest of the sites. The non-acoustical parameters studied are:

1) Age of respondents
2) Educational level
3) Income
4) Sex of respondent
5) Amount of time spent at home

Cross-tabulation is useful to study if any significant relationship exists between the dependent variable and a particular independent variable when the masking effects of other independent variables have been excluded. This assumes that either the sample size is large enough or the sample has been preselected, to ensure that such masking effects can be excluded. For example, if one wishes to check if the age of the respondents affects their response to noise related questions, it would be necessary to exclude the effects of other variables such as noise levels, sex, the exposure time to such noise, etc. Unfortunately, the effect of cross-tabulation is to severely reduce the sample size, that is to say, the number of male respondents between the ages of 25 and 35 years, all exposed to roughly the same level of

noise for about the same time duration, will be relatively small. In fact it may be too small to come to any statistically valid conclusion. Hence, cross-tabulations should only be viewed as rough guides. Any final and definitive conclusion must await more sophisticated analysis such as multiple regression, partial correlation, etc.

(ii) Disturbed in General by Industrial/Traffic Noise Cross-Tabulated With Age of Respondents

This is displayed in Fig.38. Where the number of respondents in a group or category is less than 20, the response has not been marked. No particular trend is evident from this display. It would appear that respondents over 60 years of age are less disturbed than the others. However, whether this effect is due to age or due to some other reason such as habituation, hearing loss, is difficult to judge.

NSANY 2 is shown cross-tabulated with age in Fig. 39. Again, the group over 60 years of age had the least percentage disturbed by traffic noise.

(iii) NSANY 1, NSANY 2 Cross-Tabulated With Educational Level

These are displayed in Figures 40 and 41 respectively. A rather interesting trend is seen. Whereas for traffic noise the responses are uniform for all groups, for industry noise there is a definite upward trend. Respondents with a higher level of education appear to be more sensitive to industry noise. The masking effect in this case could be income and type of occupation. However noise level itself is not a significant variable in this instance, since the majority of respondents with higher educational level are from the Windsor area (see Fig. 8).

(iv) NSANY 1 and NSANY 2 Cross-Tabulated With Income of Respondents

Figs. 42 and 43 respectively show the cross-tabulation of NSANY 1 and NSANY 2 with total household income of respondents. There were insufficient numbers of respondents in the groups over $20,000. Significant numbers of respondents also refused to divulge information about their income. The resulting displays do not reveal any significant information.

(v) NSANY 1 and NSANY 2 Cross-Tabulated With Sex of Respondents

These are shown in Fig. 44. No significant difference between the reactions of males and females towards either industry or traffic noise can be observed.

(vi) NSANY 1 and NSANY 2 Cross-Tabulated With the Amount of Time Spent at Home During Weekday Daytime Hours by the Respondents

These are displayed in Figures 45 and 46 respectively. This particular independent variable does not appear to have a significant effect on the response to either industry or traffic noise.

# V CORRELATION ANALYSIS

## V (a) Levels of Measurements

Correlation and regression analysis are higher levels of statistical analysis than either tabulation or cross-tabulation. In order to utilize these higher level statistical tools, one must have an idea of their limitations both on the type of input data and on the interpretation of results. For this reason a brief discussion is given below on levels of measurement, types of analysis suitable for particular levels of data and the interpretation of the results obtained from such analysis. The material below is a summary of the discussion given in the manual "Statistical Package for the Social Science" (Ref. 11).

In general there are four levels of measuring data:

1) Nominal
2) Ordinal
3) Interval
4) Ratio

In addition to the above there is a special case called "Dichotomy".

The nominal level of measurement is the most basic of the set. No assumption of ordering or distance between categories is made. The place of birth of a person, race, colour of eyes, etc. are nominal level data. Statistics which assume ordering or meaningful numerical distance between the categories should not be used. Simple tabulation or cross-tabulation can be used.

The Ordinal level of measurement assumes that it is possible to rank-order the categories. For example, classification of educational level as primary, secondary and post secondary is rank ordering. Each category has a unique position relative to the other categories. However, the distance between categories is not known, i.e. we do not know how much higher on the educational scale post-secondary is compared to primary.

Interval level data can be rank ordered and assigned fixed, equal, distances between categories. Number of years of education for example would be in this category. However, if a person has 10 years of education and another 5 years, it is not possible to say that the former has half as much "education" as the latter.

Ratio level measurement can be rank ordered, it has fixed equal distances between categories and the ratio of the distance between categories is meaningful. The age of a person is ratio level data. One can say that a 40 year old man is twice as old as a 20 year old man.

Finally we come to the case of dichotomies. This is a variable which has only two possible categories, ex. sex (male or female). The response to questions such as "Are you disturbed by noise? Please answer yes or no", is dichotomous. Dichotomies can be treated as though they were interval level and sometimes even ratio level data depending on the research situation.

It should be noted that statistics developed for the lower level of measurement can always be used with higher level data, but the reverse is not valid. For example, the mean, median, etc. assume ordinal level data. However, they can be used for interval or ratio levels as well. On the other hand, regression analysis requires at least interval level data and cannot be used with nominal or ordinal level data.

V. (b) Variables Used in the Analysis

In the present study, the following variables have been identified for higher level statistical analysis.

(i) Independent Variables

These can be subdivided into two distinct categories.

(1) variables based on physical measurements of the

acoustical environment (2) variables related to the personal characteristics of respondents.

The independent variables which are direct physical measurements of the acoustical environment are as follows:

(1) Spot percentile levels ($L_{90}$, $L_{50}$, $L_{10}$);

(2) Spot equivalent sound level ($L_{eq}$);

(3) Measurements of impulse noise alone using A-weighted, Fast and Slow response settings (dBA Fast, dBA Slow);

(4) Measurements of impulse noise alone using A-weighted, impulse response setting (dBAI WM, dBAI 10).

All of the above variables were obtained from analogue recordings of the noise climate in the survey areas taken when forge noise was audible. The percentiles and $L_{eq}$ are measurements of not only the forge noise but of the general noise climate as well which includes noise from vehicular traffic, people noise etc. In fact, as one moves away from the forge plants, very rapidly the contribution from the impulse noise is considerably reduced and these measurements are generally dominated by local traffic noise and people noise.

The fast, slow and impulse response levels are measurements of only the impulse noise. The fast and slow response levels are simple arithmetic averages. From the impulse response levels, the weighted mean level (dBAI weighted mean) and the level exceeded by 10% of the impulses (dBAI 10) have been calculated as explained in Section III (c).

From these measured spot levels, some new independent variables were computed. These comprise the difference between the spot impulse levels and the spot $L_{90}$, $L_{50}$ and $L_{eq}$.

As noted in Section II (b), in addition to the short term analogue recordings, 24 hour digital monitoring was carried out at locations where the forge noise levels would not contribute significantly to the acoustical energy. From these monitors, $L_{90}$, $L_{50}$, $L_{10}$ and $L_{eq}$ values were obtained for daytime (7 am to 7 pm), evening (7 pm to 11 pm), night time (11 pm to 7 am) and all day (24 hours). The difference between the spot impulse levels and the long term $L_{90}$, $L_{50}$ and $L_{eq}$ was computed.

The following variables related to the personal characteristics of respondents have been identified for this analysis:

(1) Age,

(2) Number of years of residence at present location,

(3) Number of hours spent at home during weekday, daytime hours,

(4) Income,

(5) Educational level.

(6) Occupation.

(7) Sex.

In addition to the above, certain groupings can be made such as:

(1) Sensitivity to noise,

(2) Socio-economic status.

The personal variables identified above are of interest when one is attempting to account for that part of the variability of response which cannot be accounted for by physical measurements of noise. Analysis such as partial correlation and multiple regression would then be needed. In this report, personal variables have not been taken into account.

In addition to the two categories of independent variables outlined above, there are some others which cannot be easily categorized. There are:-

(1) distance from forge,

(2) frequency of audibility.

(ii) Dependent Variables

From the sociological survey questionnaire, it is possible to obtain directly the following dependent variables for each quesiton related to noise.

(1) Voluntary dislike (Question 2 b ).

(2) Elicited disturbed (Question 8 d).

(3) Windows closed (8 f).

(4) Feature (14).

(5) Indoor activity disturbed (16 d).

(6) Outdoor activity disturbed (17 c).

(7) Sleep disturbed (18 d).

(8) Windows closed (18 e).

Some of the variables listed above have been combined to give new variables which reflect overall reaction to noise. The variable , "Disturbed any way by noise" has been created to measure general negative reaction to noise. Any negative response be it voluntary, elicited, activity disturbed or sleep, is considered as disturbed in general with no weighting placedon either the type or number of negative responses.

The variable "Voluntary dislike" has been created by considering the negative response to either of the questions 2(b) or 14. This does not include negative responses to any of the other noise related questions.

A third variable "NUMBIND" has been created by adding the negative reactions to all the questions on noise. A maximum score of 8 is possible. This variable gives an interval scale but not a ratio scale. All the others are dichotomous, i.e. disturbed or not disturbed.

Finally the variable MOTH was created to indicate that a respondent was disturbed more than one way by noise e.g. elicited disturbed and sleep disturbed.

Tables 3 and 4 show the list of independent and dependent variables used in the analysis.

V. (c) Correlations Using Individual Data

Before presenting the results of correlation analysis, it is necessary to consider the type of data obtained in this survey. In most community surveys, a large number of independent sites are chosen to adequately cover the range of variables one is interested in examining. Each site should consist of at least 30 to 40 respondents. The average response from each of the sites is then examined, i.e. Percent of respondents at each site who are disturbed. This can be considered as ratio level measurement. However, in the present case, there are only 3 truly independent sites, i.e. Welland, Port Colborne, and Windsor. This is insufficient for purposes of analysis such as correlation or regression. Consequently the analysis has been carried out in two ways. Firstly, the data has been analysed on an individual basis. Secondly, groups of respondents have been artificially created, either on a geographical basis or on the basis of their noise environment. Average responses have been obtained for these groups and analysis carried out on these averaged values recognizing that not all the groups are truly independent sites.

The use of individual data for analysis such as correlation and regression appears to have advantages. Firstly, detailed information related to individual respondents is preserved. In the case of grouped responses, since only averaged information is used much of the detail is lost. Secondly, the sample size is considerably larger when individual data is used. Thus, one should be able to generalize with a greater degree of confidence. This is due to the fact that as the number of degrees of freedom increases the variability of the computed correlation coefficient is reduced. For example, if the correlation coefficient between two variables is 0.6, and this value is based on a sample size of 20, based on a confidence level of 99% the spread of r would be from .05 to .85. On the other hand if it were based on 200 samples, the spread of r would be .49 to .7 (Ref.12).

V. (d) Types of Correlations Computed

There are a number of tests of association that one could use to determine whether any two variables are related to each other, and if so, to what degree i.e the strength of the relationship. In general they can be categorized into parametric or non-parametric tests. The parametric tests assume that the observations are randomly drawn from a population with known functional form such as the normal distribution. On the other hand the non-parametric tests do not make such assumptions. These statistics need only an ordinal level of measurement and a large number of categories or ranks on each of the variables. They are basically designed to determine whether two rankings of the same cases are similar.

As the individual response data is of a dichotomous nature. it was decided to compute both the parametric and non-parametric statistics. The following statistics have been computed:

(1) Chi square

(2) Tau C

(3) Pearson product-moment correlation

(4) Kendall's rank order correlation

The chi square test is well known and does not need any explanation here. It assumes that the variables are measured at the nominal level.

The Tau C test assumes ordinal level variables. In this test each pair of cases is considered and ordered into "concordant", "discordant" or "tied" categories. For example, if we have four respondents A, B, C, D, who are exposed to noise levels 50, 55, 60, 65 dBAI and their responses are 0, 1, 1, 0 (0 = not disturbed, 1 = disturbed) respectively, comparison of A to B would give a concordant pair ($50 < 55, 0 < 1$), A to C would give a concordant pair ($50 < 60$, $0 < 1$). Comparison of B to D would give a discordant pair ($55 < 65$, $1 > 0$). Comparison of B to C would give a tied pair ($55 < 60$, $1 = 1$). Thus, the total number of concordant(P), discordant (Q) and tied pairs (T) are counted by comparing every case with every other case. If $P < Q$, Tau C will be positive and if $P > Q$, Tau C will be negative. The actual value is computed taking into account the tied pairs as well. Tau C can take on values from -1 to +1.

The Pearson product-moment correlation coefficient (r) is the most commonly used measure of association for interval and ratio level data. It is also a measure of the goodness of fit of linear regression. $r^2$ is a measure of the proportion of variance in one variable explained by the other. Mathematically,

$$r = \frac{\sum_{i=1}^{N} (x_i - \bar{x})(y_i - \bar{y})}{\left[ \sum_{i=1}^{N} (x_i - \bar{x})^2 \sum_{i=1}^{N} (y_i - \bar{y})^2 \right]^{\frac{1}{2}}}$$

where, $x_i$ and $y_i$ are the ith value of the variables x, y, N is the number of observations, $\bar{x}$ and $\bar{y}$ are the mean values of x and y.

Kendall's tau is a non-parametric measure of association It requres ordinal level of measurement. It is also based on rank ordering and could vary from +1 to -1. A special statistic S is computed based on rank ordering. Details are given in Ref. 11.

Each of these measures of association can be tested for levels of significance. The chi square test has its own distribution which is dependent on the number of degrees of freedom of the system.

The significance of the statistic Tau C is obtained by comparing the value obtained assuming a normal distribution. For example if Tau C has a value $T_1$ at a level of significance of .001, it simply means that there would be 1 chance in 1000 that the correlation may have resulted by accident i.e. the association between the two variables is not due to random chance if we accept the level of signficance at .001.

The significance test for the Pearson correlation is based on Student's t distribution with N-2 degrees of freedom. For the non-parametric Kendal's tau, the significance is obtained by comparing tau to a normal distribution with a standard deviation equal to:

$$\left\{ \frac{4\ N + 10}{9\ N\ (N-1)} \right\}$$

where N is the number of cases or observations.

V. (e) Results of Correlation Analysis

Correlations for industry noise were first computed taking NSANY 1 as the dependent variable and the complete set of measured and calculated noise levels as independent variables. From this, a subset of 6 independent variables was chosen. The choice was made based on two criteria:

(1) The strength of the correlations

(2) The practicability of using the descriptor for enforcement purposes.

These 6 independent variables were then correlated with the remaining dependent variables for industry noise. A similar strategy was used to correlate traffic noise data. For traffic noise the number of measured independent variables is much smaller. The table below shows the variable pairs used for computing correlations.

| Dependent variable | | Independent variable |
|---|---|---|
| NSANY 1 | with | All the measured and computed levels of impulse noise (see Table 3) |
| NSANY 2 | with | SLEQ, S90, S50, S10 |
| NSANY 3 | with | SLEQ, S90, S60, S10 |
| VOLIND, GNIND<br>GNINDWND, ININD<br>OUTIND, SLIND<br>SLINDWND, NUMBIND | with | IMPWM, IMP10, IMPWM-E90, IMP10-E90<br>IMPWM - SLEQ, IMP10 - SLEQ |
| VOLTR, GNTR<br>GNTRWND, INTR<br>OUTR, SLTR<br>SLTRWND, NUMBTR | with | SLEQ |

Table 5 lists the correlations. Within each category, the correlations have been listed in the order of decreasing value of the Kendal Tau correlation. It is seen that the rank ordering by Kendal Tau is different than that by the other measures of association. That is, according to the Kendal Tau test, IMP10 - E90 correlates best with NSANY 1 ($\tau = 0.25$) Pearson correlation would suggest IMPWM - SLEQ ($r = .31$) as the best correlator. This indicates the need to examine more than one statistic in order to assess the strength of relationships. However, in this case the actual values would indicate that the rank ordering is fairly similar, regardless of the statistic considered. The following general conclusions can be drawn from Table 5.

(1) In general, the impulse levels above ambient are better correlated with NSANY1 than the impulse levels alone.

(2) For best correlation either the spot $L_{eq}$ or the evening $L_{90}$ should be used to describe the ambient.

(3) General descriptors of the local noise environment such as Spot $L_{eq}$ or spot percentiles are poorly correlated with NSANY1.

(4) IMP10 and IMPWM both appear to be equally well correlated with NSANY1.

From an examination of the correlation coefficients in Table 5, a set of 6 independent variables were chosen to compute correlation with other dependent variables. IMP10 - E90, IMPWM - E90, IMP10 - SLEQ and IMPWM - SLEQ were chosen because they were the best correlators (based on Tau C and Kendal's Tau values). In addition, IMPWM and IMP10 were chosen from the standpoint of ease of measurement for enforcement purposes.

The correlation between the selected independent variables and the other dependent variables for industry noise are shown in Part II of Table 5. It is seen that these correlations in general are smaller than the corresponding correlation with NSANY1.

Similar computations for traffic noise are also shown in Table 5. In general, traffic noise correlations are not as good as those for industry noise. Spot $L_{eq}$ is best correlated with NSANY2. Consequently, additional correlations of Spot $L_{eq}$ with the other traffic noise dependent variables were calculated and are shown in Part II of Table 5.

Finally, correlations between NSANY3, (disturbed in general by other noise), and general descriptors of noise such as Spot $L_{eq}$ were computed and did not show any significant trend. Additional correlations were not computed.

## VI REGRESSION ANALYSIS USING INDIVIDUAL DATA

### (a) General comments

Regression analysis is the final goal of this programme. It gives the functional relationship between the dependent variable - in this case the percent of people disturbed by noise - and the independent variable, which is a physical measure of noise. This of course permits the calculation of the dependent variable given a value of the independent variable or vice versa.

In general, regression analysis requires interval level variables. Noise levels of course do satisfy that condition. However, the response is dichotomous. The discussion in Section V(c) on individual as opposed to grouped data is applicable here as well. However, the meaning of regression when applied to individual data becomes less clear. A brief discussion of the implications of regression analysis using individual data is given below. It is in fact a summary of the discussion given in Ref. 13.

Responses of the type obtained in this survey are called "Quantal" responses. The term refers to responses which permit no gradation and can be expressed only as "occurring" or "not-occurring"; in this instance whether "disturbed" or "not-disturbed". This type of a response is based on the premise that when a stimulus is applied to a subject, it will or will not evoke a response depending on the intensity. For any given subject, below a certain threshold of the stimulus, there will be no response and above that threshold there will be a response. This concept is widely used in biological testing. In the present case it would imply that there exists a noise level below which an individual would not be disturbed (or annoyed) and above which he would be disturbed (or annoyed). The value of this threshold

level will be different for different people. It may be dependent on variables unrelated to the situation.

Discussion of quantal response involves assumptions of the distribution of the threshold value. If the intensity of the stimulus is measured by z , we can write

$$dP = f\ (z)\ dz \tag{1}$$

where dP is the proportion of the whole population whose threshold value lies between z and z + dz. f (z) is known as the frequency function.

Equation (1) may be viewed in the following manner. If a fraction P of the population has a threshold value of z increasing z by a small amount dz will result in an increase in P, to P + dP. The function f(z) relates dP to dz. By the same token, the proportion of the population whose threshold value is equal to or less than $z_o$ is given by

$$P = \int_0^{z_o} f(z)\ dz \tag{2}$$

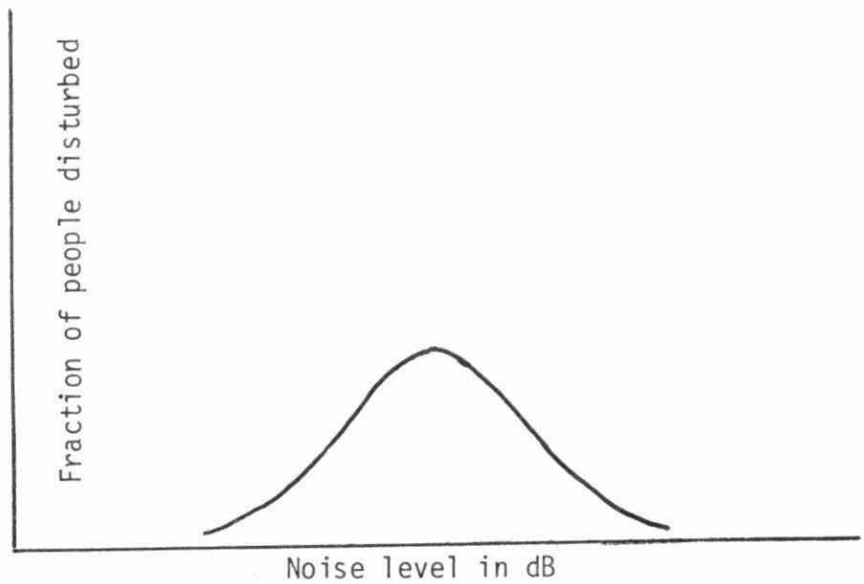
It is also assumed that

$$\int_0^{\infty} f(z)\ dz = 1 \tag{3}$$

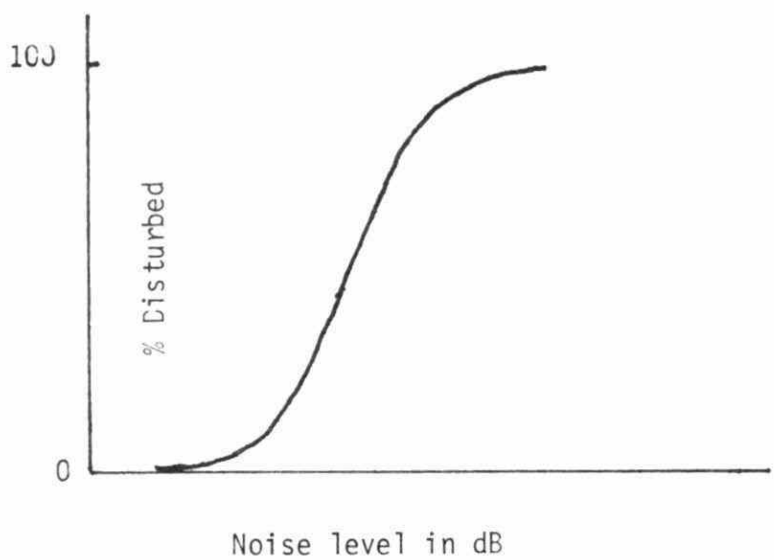
Eq (3) implies that response is certain for very high values of the stimulus.

It is clear that if we could define f(z), we would have a relationship between the proportion of subjects responding and the stimulus, which could then be used to calculate the response of the population. The distribution of f(z) is usually skew but with a transformed scale it will convert to a gaussian or normal distribution. The implication of this is that in any population there will be some subjects who will be disturbed (or annoyed) no matter how low the noise level is and there will

be some who will not be disturbed (or annoyed) even at very high noise levels and the distribution in between will be gaussian (Figure below). The theoretical curve extends from $-\infty$ to $+\infty$




The cummulative distribtuion can be obtained from the Gaussian frequency distribution as shown in the figure below. It is known as a "normal sigmoidal curve".



Assuming a normal distribution eq. 1 can be written as

$$dP = \frac{1}{\sigma\sqrt{2\pi}} \exp\left\{-\frac{(x-\mu)^2}{2\sigma^2}\right\} dx \tag{4}$$

(where x represents the dose of the stimulus). The parameters $\mu$ and $\sigma$ are respectively the mean and standard derivation of the distribution. If $\mu$ and $\sigma$ are known, P can be readily computed:

$$P = \int_{-\infty}^{X} \frac{1}{\sigma\sqrt{2\pi}} \exp\left\{-\frac{(x-\mu)^2}{2\sigma^2}\right\} dx \tag{5}$$

Now, suppose we measure the probability of response on a transformed scale (as opposed to the dichotomous response) as follows:

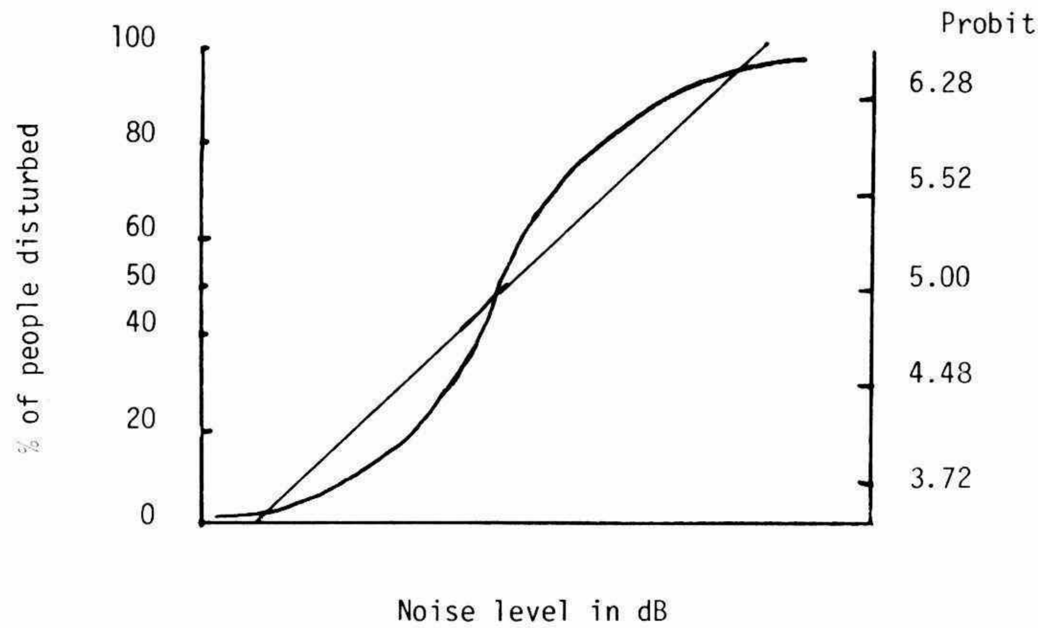
$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y} \exp\left(-\frac{u^2}{2}\right) du \tag{6}$$

It is seen that as P ranges in value from 0 to 1, Y ranges from $-\infty$ to $+\infty$. The transformation stretches the extremes of the scale. Y is known as the "Normal Equivalent Deviate" (or NED). On comparing equations 5 and 6, it can be shown that

$$Y = \frac{(X-\mu)}{\sigma} \tag{7}$$

This shows that the dose of the stimulus and NED of the probability of response at that dose is a straight line.

The Figure below shows the relationship between noise level and response if plotted using the transformed scale.




In the above Figure a value (Y + 5) known as the "Probit" of P (probability unit of P) is shown plotted. The relation between the probit of the expected proportion of the response and the dose is

$$Y = 5 + \frac{(x - \mu)}{\sigma} \equiv \alpha + \beta x \qquad (8)$$

The values of $\alpha$ and $\beta$ can be obtained by regression using experimentally measured values of $x$.

The above discussion indicates that regression analysis of individual response data may yield results which would be under estimates at high noise levels and over estimates at low noise levels. The degree of error would depend on the shape of the underlying distribution. Analysis of the type discussed above, known as Probit Analysis, would yield improved results. It is expected to carry out Probit Analysis at a future date. For the present, results of simple bivariate regression are presented below.

VI. (b) Results of Bivariate Regression using individual data

The results of bivariate regression analysis using individual response data is shown in Table 6. The scheme of computation was similar to that used for computing correlations. Disturbed in general by industry noise was used as the dependent variable and regressed on all the measures of impulsive noise. Subsequently the remaining dependent variables were regressed on a subset of six descriptors (same as the ones chosen for correlation analysis earlier), the same strategy being used for traffic noise. The independent variables have been arranged in order of the correlation coefficients. The significance level of the correlations, the slopes and the intercepts of the regression lines are also shown.

## VII Bivariate Regression Using Grouped Responses

### (a) Introduction

Analysis of grouped responses is the more traditional approach in community noise surveys. This is especially true of regression analysis. In the present study two different types of groupings have been made:

(1) Grouping based on noise level.

(2) Grouping based on geographical location of respondent.

In the first method of grouping, respondents were sorted and arranged in an ascending order of noise level (for any given descriptor) at each of the three sites i.e. Welland, Port Colborne and Windsor. Contiguous groups of from 30 to 33 respondents were then created. In this method, all the people in a given group may not necessarily live in the immediate neighbourhood of each other. If one assumes that typical neighbourhood characteristics, such as type of housing, income level, etc. vary gradually in a given community, this method of grouping may very well place respondents of quite different socio-economic backgrounds in the same group, which will tend to confound the issue.

The second type of grouping was created by forming subsets of from 30 to 35 respondents each who lived relatively close to each other. A total of 19 such groups were formed. Average values of the noise level were computed for each group ( for a specific descriptor of noise). The response of each group was calculated as a percent of people disturbed in the group (for a dependent variable). The percent of people disturbed was then regressed on the average noise level. The process of grouping,

averaging and regression is quite time consuming and expensive (i.e. computer time and cost). Consequently three specific noise descriptors were chosen for this analysis. These are IMPWM - E90, IMPWM - SLEQ, and IMPWM. The first descriptor was chosen since it appeared to correlate best with response (Sec.V (e) ). The second descriptor also correlates very well with response and it has the added advantage that it is more easily applicable for enforcement purposes. The spot $L_{eq}$ in most cases can be calculated based on local traffic noise. The third descriptor was chosen, although it correlated less well with response than the others, again from the viewpoint of ease of enforcement. Each of these descriptors was then regressed on all the dependent variables for each type of grouping.

For regression analysis of traffic noise, Spot $L_{eq}$ was chosen as the independent variable and regressed on all the dependent variables of traffic noise response.

VII (b) Effect of size of grouping

Regardless of the type of grouping, it is clear that each group must have approximately the same number of people in it. Otherwise, one would have to weight responses depending on the size of the group. The size of each group is also important. If there are too few respondents per group, the results will tend to be highly variable and statistical significance will be lost.

If there are too many respondents per group, the total number of points available for regression will be reduced. Also, any real variability that may exist will be averaged out in the calculation of average noise levels, the averaging will be over too wide a band of levels.

Fig. 47 shows the regression of NSANY 1 on IMPWM. The responses have been sorted by ascending order of IMPWM and each group has 25 respondents. The results when the group size is increased to 50 respondents, are shown in the next figure (Fig. 48 ). It is seen that doubling the group size increased the correlation coefficient from 0.55 to 0.81 and reduced the standard error of estimate from 17% to 9%. The slope of the regression line is slightly increased from 1.881 to 1.983.

Figures 49 and 50 show the results of using VOLIND as the dependent variable. Increasing the group size from 25 to 50 results in increasing the correlation coefficient from 0.59 to 0.87 and decreasing the standard error of estimate from 10.2% to 4.6%.

On comparing Figures 47 and 48 it is seen that what appears to be significant variation in response at levels of from 48 to 52 dBAI WM in the former figure have been smoothed out in the latter figure. On examining the data more carefully, it was found that the high response at the low levels was a real effect reflecting the attitude of residents in a new subdivision in Windsor.

From the above discussion it is seen that the size of grouping has a significant effect on the results. It was decided that for all succeeding computation, groups of from 30 to 35 respondents would be the optimum.

VII (c) Results of the regression analysis of data grouped in order of noise level

(i) Grouped in ascending order of IMPWM within each site

The responses from each site were sorted and arranged in ascending order of IMPWM within each site. A total of 19 groups was formed, each containing an average of 32 respondents. 14 groups were formed from the 447 respondents in Welland, 2 groups from the 61 respondents in Port Colborne and 3 groups from the 99 respondents in Windsor. It had been noted (See Figs. 3,16) that within the area surveyed in Windsor, two distinct subdivisions were present, one comprising of 59 respondents on Mathew Brady Boulevard and Belle Isle View and the other a relatively new community of 40 respondents on Isabel Court and Isabel Place. The groupings reflected this split and are designated WINDOLD and WINDNEW.

The regression of NSANY 1 on IMPWM is shown in Fig. 51 and that of VOLIND on IMPWM is shown in Fig. 62. The relevant statistics are also shown in the Figures. Table 8 is a listing of the statistics for the regression of all the dependent variables on IMPWM for this grouping. The Table also gives the statistics for the regressions excluding WINDNEW, and those excluding Windsor completely. It is observed that excluding WINDNEW in-

creases the correlation between NSANY 1 and IMPWM from .64 to 0.79 and excluding Windsor completely increases it to .83. The square of the correlation is a measure of the variance in response explained by noise level alone. Thus, if we include data from all the sites, noise level alone would explain about 41% of the variance in response. Excluding WINDNEW would increase this to 62.4% and excluding Windsor completely would result in 68.9% of the variance being explained by noise levels alone. This would suggest either that the responses cannot be explained properly by the noise level alone and other factors such as socio-economic status of the respondent, number of years of exposure, etc., play a significant role in explaining the response, or, that the descriptor of noise that has been chosen is not suitable. As will be seen from succeeding results, a different noise descriptor does indeed improve the correlation somewhat but not enough to discard the first alternative.

It is also seen that excluding all of the Windsor data results in only marginal improvement in explained variance. This would suggest that the variability in the response is significantly affected by the new development in Windsor.

(ii) Grouped in ascending order of IMPWME90 within each site

Figure 53 and 54 show the regression of NSANY 1 and VOLIND on IMPWME90 respectively. The statistics for the regression of all the dependent variables in IMPWME90 are given in Table 9.

On the basis of a comparison between the results for data grouped by noise level, it would appear that IMPWME90 is neither better nor worse than IMPWM in terms of correlating the responses obtained in this survey to noise level.

(iii) Grouped in ascending order of IMPWMSLQ in each site

Figures 55 and 56 show the regression of NSANY 1 and VOLIND on IMPWMSLQ respecively. The statistics for the regression of all the dependent variables on IMPWMSLQ are given in Table 10.

Correlation between the dependent variables and IMPWMSLQ is slightly better than with either IMPWM or IMPWME90. However, a slight anomaly is observed in that, excluding Windsor does not result in an increase in correlation. This is attributed to the method of grouping the data, since, with the same noise descriptor, for data geographically grouped, the expected increase is observed. This is shown in the next section

(iv) Grouped in ascending order of Spot Leq, within each site

Reaction to traffic noise has been regressed on spot $L_{eq}$. This is shown in Fig. 57. Table 11 lists the statistics of the regression of all the dependent variables of traffic noise on Spot $L_{eq}$. In general the correlation between reaction and noise level is about the same or a little worse than that for industry noise. However, the striking difference is that in the latter case, correlation was significantly improved when data from the new subdivision in Windsor was excluded. In the case of traffic noise response, no such improvement is seen. This would indicate that the responses are spread fairly uniformly over all the sites. This may be attributed to the fact that the type of traffic in the sites surveyed was strictly of a local nature. There were no major thoroughfares or highways close to any of the sites. Comparison of the reaction to traffic noise with that due to industry as well as with results of other surveys will be given in a subsequent section.

VII (d) Results of regression analysis of data grouped geographically

NSANY 1 has been regressed on IMPWM for geographically grouped responses. Figures 58 to 61 show the results for four different cases:

(1) Including groups from all sites (i.e. Welland, Port Colborne, WINDNEW, WINDOLD);

(2) Excluding WINDNEW;

(3) Excluding Windsor;

(4) Welland groups only.

The correlation of NSANY 1 with IMPWM for geographically grouped data is almost the same as for the grouping by IMPWM (see Fig. 51). The slope of the regression line is somewhat steeper for the former case. The standard error of estimate is higher for the geographically grouped data.

Excluding WINDNEW results in improved correlation (from .63 to .76) and reduced standard error of estimate (from 19.8% to 15.7%). Excluding all of Windsor results in only a marginal improvement in the statistics (correlation increases from .76 to .79). Excluding both Windsor and Port Colborne, i.e. for Welland responses only, the results are slightly better (correlation increases to .85 and standard error of estimate reduces to 14.5%). These results are substantially similar to those obtained using data grouped according to IMPWM.

Figures 62 and 63 show the regression lines of VOLIND on IMPWM including all the groups and for only the Welland data respectively.

Figures 64 and 65 show the regression lines of NSANY 1 on IMPMSLQ. Figures 66 and 67 show the regression lines of VOLIND on IMPWMSLQ.

For the geographically grouped data, an additional dependent and independent variable for industry noise has been used for regression analysis. The dependent variable (symbol MOTH 1) includes respondents who indicated that they were disturbed in more than one way by industry noise. The independent variable chosen was the log of distance of the respondent from the dominant source.

Figure 68 shows the regression of NSANY 1 on log (distance) for all the groups and Figure 69 shows the regression line when the responses from Windsor are excluded. It is again seen that correlation coefficient increases markedly from -0.61 to -.87 and the standard error of estimate drops from 20.1% to 12.6%. The negative sign of the correlation coefficient is due to the fact that as distance increases, disturbance is reduced. The fact that distance correlates with response just as effectively as measured noise level would indicate that:

(1) Attenuation of the noise of the forges due to the buildings enclosing them is not significant at any of the sites. This was of course confirmed by visual observation.

(2) The propagation of the forge noise into the communities is not significantly different from site to site.

(3) The responses from the residents in Windsor was a reflection of the noise level prevailing in the community prior to the closing down of the plant for expansion and renovation and consequent attenuation in level.

(4) The respondents in the new sub-division in Windsor are more sensitive to the forge noise than those in the older subdivisions.

(5) The estimation of noise levels at the Windsor site based on earlier measurements would appear to be reasonable.

Regression using MOTH 1 as the dependent variable is shown in Figure 70, 71 and 72, the independent variable in all cases being log (distance). The first regression line includes all the groups, the second excludes Windsor and the third is for Welland only. With this pair of variables a correlation of -.0.956 was obtained for the Welland data with a standard error of 5.4%.

MOTH 1 has been regressed on other independent variables. The results do not indicate significantly improved correlation and so have not been included in this report.

The regression of NSANY 2 on spot Leq is shown in Fig. 33. The correlation is worse than for the data grouped by spot $L_{eq}$. The slopes of the regression lines are not significantly different from each other.

A new independent variable for traffic noise was also defined and regressed on NSANY 2. It is $L_{dn}$ or the day-night equivalent sound level. It is the 24 hour $L_{eq}$ with a 10 dB penalty on night time sound levels. It correlates marginally better than spot $L_{eq}$.

Tables 12, 13 and 14 list the statistics of the regression analysis carried out using geographically grouped data.

VII. (e) Comparison of reaction to impulse noise and traffic noise

One of the aims of examining the response to traffic noise in this survey was to provide a basis for comparison with response to impulse noise. In addition, since to the best of the knowledge of the author of this report, no other field study of community reaction to impulse noise has been reported in the open literature, it is not possible to compare the impulse noise results of this survey to those of any other survey. However, it should be possible to relate the traffic noise results from this survey to those of other surveys.

There are several factors which make even this limited comparison difficult to carry out. The measuring instrument for a sociological survey is the questionnaire. Since different surveys use different questionnaires, ambiguities arise as to the meaning of the results. For instance, in the survey conducted by Hall & Taylor (Ref. 6), they used a nine point rating of disturbance; whereas in the present survey disturbance is measured on a dichotomous scale.

The type of stimulus studied could itself be different for different surveys. In the present survey, traffic noise is a result entirely of local traffic which was generally quite sparse.

Hall and Taylor chose a number of sites with a wide variety of traffic.

Comparing the present response to traffic and that to impulse noise does ensure that at least the measuring instrument is the same in both cases. However, calculations on response to impulse noise have been carried out using impulse level as a descriptor whereas traffic noise correlated best with $L_{eq}$. Consequently, a direct comparison becomes difficult.

Keeping the above cautionary points in mind, an attempt has been made to compare:

(1) results of response to impulse noise and traffic noise as obtained in this survey;

(2) results of response to traffic noise as obtained in this survey with those from other surveys.

In general it would appear that reaction to traffic noise was fairly uniform at all the sites. Even though traffic was considered by many to be a factor that they disliked in their neighbourhood, it appeared that other aspects related to traffic, such as safety for children, was more the culprit than noise. The reaction was the opposite for impulse noise. This, of course, is to be expected.

Within the sample studied in this survey, it appeared that socio-economic status of the respondent did not play a significant role in response to traffic noise. Socio-economic status does seem to play an important role in response to impulse noise as evidenced by the fact that correlation significantly increases if WINDNEW is excluded from the analysis.

In terms of numbers, if we examine the dependent variables NSANY 1 and SRANY 2, we get, for 50% of people distrubed, 51 dBAI WM for impulse noise and 66 dBA (Spot $L_{eq}$) for traffic noise. If WINDNEW is excluded from the analysis for impulse noise, we would have 62 dBAI WM.

In terms of energy it is possible to make a rough calculation to show that the energy contributed by the forge noise is quite small compared to that from local traffic. From the uv chart recording for location 15 in Welland, the following data is obtained:

| | |
|---|---|
| Duration of record= | 14 minutes |
| Number of vehicles= | 11 |
| Max. sound level ($L_{max}$) due to vehicles= | 70 dBA |
| Background sound level= | 52 dBA |
| Duration of sound level from a vehicle= | 4 secs. |

For a series of 'n' , triangular, identical, time patterns having a maximum level of $L_{max}$,

$$Leq = L_b + 10 \log \left[ 1 + \frac{n\tau}{T} \left( \frac{10^{\Delta L/10} - 1}{2.3} - \frac{\Delta L}{10} \right) \right]$$

where, the duration between ($L_{max}$ - 10 dB) points is $\tau$ seconds, the background level is $L_b$, and the total time period is T(Ref. 14). For the data given above,

$L_{eq} - L_b$ = 5 dB

$L_{eq}$ = 57 dB

The measured spot $L_{eq}$ at that location was 58 dBA. This includes energy contributions from traffic as well as the forge noise. The calculation above would indicate that almost all the energy was contributed by traffic. The impulse level at that location was 59 dBAI WM and it was practically continuous for the duration of the recording. It would appear from this survey that in terms of equal energy, respondents were more disturbed by impulse noise than by traffic noise. This of course only confirms the longstanding view that a 5 to 10 dB penalty is added to noise of an impulsive nature (Ref. 4).

Next, a comparison is made between the reaction to traffic noise as obtained in this survey, to that from another survey. Hall and Taylor (Ref. 6) give the following relationship between the percent of

people "at all disturbed" and $L_{eq}$ (day).

$$\% \text{ disturbed} = -124 + 2.6\ L_{eq}$$

For 50% of people disturbed, $L_{eq}$ = 67 dBA which, fortuitously, is only 1 dBA above the value predicted by the present survey. However, both the slope and the intercept of the regression line of NSANY 2 on Spot Leq are less than those obtained by Hall and Taylor.

$$\% \text{ disturbed} = -43.4 + 1.42\ L_{eq}$$

The errors are more serious at both the low and high ends of the noise level.

## Conclusions

1. The noise from forging operations has a significant effect on neighbouring communities.

2. A new housing development in the City of Windsor appears to be far more sensitive to forge noise than the other areas surveyed. Whether this is a habituation effect or whether it is due to other socio-economic factors is not very clear.

3. Negative reaction to impulse noise appears to be greater than that to traffic noise of the same equivalent energy.

4. The best physical descriptor of noise is the impulse level above ambient, where ambient is best described by either the evening $L_{90}$ or $L_{eq}$ at a given location (which is mainly influenced by traffic noise)

5. Specific measures of impulse noise alone, using the impulse response setting of a Type 1 sound level meter, also correlates well with response.

## Recommendations for further work

1. Further computer analysis should be carried out using more sophisticated statistical tools such as probit analysis.

2. Partial correlations and multiple regression analysis should be carried out to investigate the effects of non-acoustical parameters on response.

## REFERENCES


1. Manuel, J., "Ontario Model Municipal Noise Control By-Law", Internoise 1975 Proceedings, Sendai, Japan.

2. Taylor, A.G., "Quarry Blast Atmospheric Wave (Concussion) Response of Structures and Human Annoyance" University of Toronto, Master of Engineering Project Report. Ontario Ministry of the Environment Publication, 1975.

3. Hemingway, J.R., "The Assessment of Annoyance due to Train Noise", Acoustics and Noise Control in Canada, Oct. 1976, Vol. 4. No. 4.

4. Kryter, K.D., "The Effects of Noise on Man" Academic Press, 1970.

5. Document No. SR (63) 27, dated Sept. 5, 1963, of the "Organization for Economic Co-operation and Development". Referenced in "Transportation Noises", p. 224, edited by J.D. Chalupnik, Ann Arbour Science, 1977.

6. Hall, F.L. and Taylor, S.M., "Community Response to Noise in the Toronto Hamilton Urban Corridor", Experience'75 Report. Ontario Ministry of the Environment, Feb. 1976.

7. Privacy Barrier Impact Study, Questionnaire used by the Ontario Ministry of Transportation and Commlnications, Human and Social Factors Research, Oct. 1975.

8. Koczkur, E. et al "Noise Monitoring and a Sociological Survey in the City of Toronto", Journal of the Air Pollution Control Association, Vol. 23, No. 2, Feb. 1973.

9. Harvey, E.B., "London-Woodstock Noise Survey" Report submitted to Ontario Ministry of the Environment, October, 1973.

10. Reif, Z.F., "Neighbourhood Noise Survey of Great Lakes Forgings Plant", Report No. IRI 7-24 of the Industrial Research Institute of the University of Windsor, May 1974.

11. Nie, N.H., et al "Statistical Package for the Social Sciences" Second Edition, McGraw Hill Book Co., 1970.

12. Wine, R.L., "Statistics for Scientists and Engineers", Prentice Hall Inc., 1964.

13. Finney, D.J., "Probit Analysis" University Press, Cambridge, 1971.

14. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety" U.S. Environmental Protection Agency, Doc. No. 550/9-74-004, March 1974.

TABLE 1 Survey Statistics

| | Welland | P.C. | Windsor |
|---|---|---|---|
| Total No. of persons contacted | 561 | 67 | 140 |
| % completed interviews | 80 | 91 | 71 |
| % refused interviews | 20 | 9 | 29 |
| Total No. of households | 360 | 49 | 134 |
| % missed | 8 | 4 | 25 |

TABLE 2 Number of "likes" and "dislikes" per person in Welland

| | S. Welland | N. Welland |
|---|---|---|
| No. of voluntary likes/respondent | 2.04 | 1.85 |
| No. of voluntary dislikes/respondent | .98 | 1.54 |
| No. of elicited likes/respondent | 6.92 | 6.19 |
| No. of elicited dislikes/respondent | 1.74 | 2.65 |

Vol. responses from Q. 2a, b

Elicited responses from 3, 4, 5, 6a, 7, 8a, 9a, 10, 11a, 12a, and 13a.

Table 3: List of Independent Variables

Spot percentiles: Percentile levels obtained from analogue recordings at each location, $L_{10}$, $L_{50}$, $L_{90}$. Variable names S10, S50, S90. Applicable to Industry, Traffic and Other noise.

Spot equivalent sound level: $L_{eq}$ obtained from analogue recordings at each location, variable name SLEQ. Applicable to Industry, Traffic and Other noise.

Specific measures of impulse noise: Level of impulse noise obtained from analogue recordings at each location measured using fast, slow and impulse response. Variable names FAST, SLOW, IMPWM, IMP10 or dBAF, dBAS, dBAI WM, dBAI 10. Note that FAST and SLOW are arithmetic means, IMPWM is a weighted mean and IMP10 is the impulse level exceeded 10% of the time.

Computed measures of impulse noise: Level of impulse noise obtained as a difference between the specific measures of impulse noise and an ambient level.

The ambient has been described by $L_{90}$, $L_{50}$, $L_{eq}$ obtained either from spot analogue recordings or from the long term digital monitoring. Examples are given below.

| Variable | Variable Name |
|---|---|
| dBAI WM - Spot $L_{50}$ | IMPWMS50 |
| dBAI WM - Day $L_{50}$ | IMPWMD50 |
| dBAI 10 - Spot $L_{eq}$ | IMPIOSLQ |
| dBAI 10 - All day $L_{eq}$ | IMPIOLLQ |
| etc. | etc. |

A total of 30 of these variables were computed.

TABLE 4: Dependent Variables

| | |
|---|---|
| NSANY 1: | Disturbed any way by industry noise |
| NSANY 2: | Disturbed any way by traffic noise |
| NSANY 3: | Disturbed any way by other noise |
| VOLIND: | Voluntary response, dislike industry noise |
| VOLTR: | Voluntary response, dislike traffic noise |
| GNIND: | Elicited response, disturbed by industry noise |
| GNTR: | Elicited response, disturbed by traffic noise |
| GNINDWND: | Elicited, windows closed due to industry noise |
| GNTRWND: | Elicited, windows closed due to traffic noise |
| ININD: | Indoor activity disturbed by industry noise |
| INTR: | Indoor activity disturbed by traffic noise |
| OUTIND: | Outdoor activity disturbed by industry noise |
| OUTR: | Outdoor activity disturbed by traffic noise |
| SLIND: | Sleep disturbed by industry noise |
| SLTR: | Sleep distrubed by traffic noise |
| SLINDWND: | Sleep disturbed by industry noise, windows closed |
| SLTRWND: | Sleep disturbed by traffic noise, windows closed |
| NUMBIND: | Number of ways disturbed by industry noise |
| NUMBTR: | Number of ways disturbed by traffic noise |
| LDIST: | Logarithm of distance from dominant industrial source |
| MOTH 1: | More than one way disturbed by industrial noise |
| MOTH 2: | More than one way disturbed by traffic noise. |

TABLE 5

## TABLE OF CORRELATION COEFFICIENTS - PART I

(Based on Individual Responses)

Dependent Variables: Disturbed in general by noise from industry (NSANY 1)

| Independent Variable | Kendal Non. Par. | Sig. Level | Pearson | Sig. Level | Raw $\chi^2$ | Deg. of Freedom | Sig. Level | $\tau_c$ | Sig. Level |
|---|---|---|---|---|---|---|---|---|---|
| IMP10 - E90 | .25 | .001 | .27 | .00001 | 125 | 26 | .0001 | .34 | .0001 |
| IMPWM - E90 | .25 | | .28 | | 118 | 27 | | .34 | |
| IMPWM - D90 | .25 | | .28 | | 103 | 23 | | .33 | |
| IMPWM - SLEQ | .25 | | .31 | | 115 | 22 | | .34 | |
| IMP10 - SLEQ | .25 | | .31 | | 111 | 21 | | .33 | |
| IMP10 - D90 | .24 | | .27 | | 106 | 23 | | .33 | |
| IMP10 - E50 | .24 | | .29 | | 101 | 24 | | .33 | |
| IMPWM - E50 | .24 | | .30 | | 104 | 25 | | .33 | |
| IMPWM - N90 | .23 | | .23 | | 99 | 23 | | .31 | |
| IMP10 - D50 | .23 | | .26 | | 86 | 26 | | .31 | |
| IMPWM - D50 | .23 | | .27 | | 104 | 27 | | .31 | |
| IMP10 - N50 | .23 | | .14 | | 105 | 25 | | .31 | |
| IMPUM - N50 | .23 | | .25 | | 101 | 25 | | .32 | |
| IMP10 - N90 | .22 | | .23 | | 95 | 23 | | .30 | |
| IMPWM - L50 | .22 | | .25 | | 107 | 25 | | .29 | |
| IMPWM - LLEQ | .22 | | .25 | | 85 | 22 | | .30 | |
| IMP10 - LLEQ | .22 | | .24 | | 85 | 22 | | .30 | |
| IMPWM - NLEQ | .22 | | .26 | | 113 | 23 | | .30 | |
| IMP10 - NLEQ | .22 | | .25 | | 92 | 22 | | .29 | |

TABLE 5 (CONT'D.)

## TABLE OF CORRELATION COEFFICIENTS - PART I

(Based on Individual Responses)

Dependent Variables: Disturbed in general by noise from industry (NSANY 1)

| Independent Variable | Kendal Non. Par. | Sig. Level | Pearson | Sig. Level | Raw $\chi^2$ | Deg. of Freedom | Sig. Level | $\tau_c$ | Sig. Level |
|---|---|---|---|---|---|---|---|---|---|
| IMP10 - L50 | .21 | .001 | .24 | .00001 | 104 | 25 | .0001 | .28 | .0001 |
| IMPWM - S50 | .21 | | .22 | | 96 | 19 | | .28 | |
| IMPWM - DLEQ | .21 | | .26 | | 86 | 25 | | .29 | |
| IMPWM - ELEQ | .21 | | .24 | | 89 | 25 | | .28 | |
| IMP10 - DLEQ | .21 | | .25 | | 82 | 24 | | .28 | |
| IMP10 - ELEQ | .20 | | .24 | | 85 | 25 | | .27 | |
| IMPWM - L90 | .20 | | .19 | | 112 | 25 | | .27 | |
| IMPWM - S90 | .20 | | .20 | | 92 | 17 | | .27 | |
| IMPWM | .19 | | .22 | | 78 | 23 | | .25 | |
| IMP10 - S50 | .19 | | .20 | | 85 | 19 | | .25 | |
| IMP10 | .18 | | .21 | | 74 | 23 | | .25 | |
| IMP10 - L90 | .18 | | .18 | | 83 | 24 | | .25 | |
| IMP10 - S50 | .18 | | .17 | | 91 | 18 | | .24 | |
| SLOW | .15 | | .16 | .0008 | 42 | 18 | .001 | .19 | .0004 |
| SLEQ | - .10 | .002 | - .10 | .005 | 78 | 19 | .0001 | - .13 | .002 |
| S90 | .08 | .009 | .08 | .030 | 82 | 17 | .0001 | .11 | .009 |
| S50 | .05 | .061 | .05 | .125 | 98 | 20 | .0001 | .07 | .06 |
| FAST | .02 | .271 | .03 | .237 | 46 | 24 | .0044 | .03 | .27 |
| S10 | .01 | .372 | - .01 | .381 | 119 | 20 | .01 | .02 | .37 |

## TABLE OF CORRELATION COEFFICIENTS - PART I

(Based on Individual Responses)

| Independent Variable | Kendal Non. Par. | Sig. Level | Pearson | Sig. Level | Raw $\chi^2$ | Deg. of Freedom | Sig. Level | $\tau_c$ | Sig. Level |
|---|---|---|---|---|---|---|---|---|---|
| Dependent Variable: Disturbed in general by noise from traffic (NSANY 2) | | | | | | | | | |
| SLEQ | .14 | .001 | .19 | .00001 | 76 | 19 | .0001 | .18 | .0001 |
| S90 | .12 | | .13 | .0007 | 55 | 17 | | .15 | .0004 |
| S50 | .12 | | .15 | .0001 | 56 | 20 | | .15 | .0004 |
| S10 | .12 | | .18 | .00001 | 65 | 20 | | .15 | .0004 |
| Dependent Variable: Disturbed in general by noise from other sources (NSANY 3) | | | | | | | | | |
| SLEQ | - .06 | .038 | - .045 | .132 | 39 | 19 | .0038 | - .079 | .038 |
| S90 | - .05 | .077 | - .054 | .093 | 39 | 20 | .007 | - .06 | .077 |
| S50 | - .01 | .360 | - .016 | .35 | 39 | 20 | .007 | - .016 | .360 |
| S90 | .01 | .431 | - .003 | .465 | 18 | 17 | .365 | .008 | .430 |

TABLE 5 (CONT'D.)

TABLE OF CORRELATION COEFFICIENTS - PART II

(Based on Individual Responses)

| Dependent Variable | Independent Variable | Kendal Non. Par. | Sig. Level | Pearson | Sig. Level | Raw $\chi^2$ | Deg. of Freedom | Sig. Level | $\tau_c$ | Sig. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| VOLIND | IMPWM | .15 | .001 | .17 | .00001 | 66 | 23 | .0001 | .17 | .0001 |
| | IMPWM-E90 | .15 | | .17 | .00002 | 71 | 27 | | .171 | |
| | IMPID-E90 | .15 | | .16 | .00006 | 75 | 26 | | .17 | |
| | IMP10 | .14 | | .16 | .00006 | 55 | 22 | | .16 | |
| | IMPWM-SLEQ | .14 | | .18 | .00001 | 58 | 22 | | .16 | |
| | IMP10-SLEQ | .13 | | .17 | .00001 | 56 | 21 | | .15 | |
| GNIND | IMP10-E90 | .15 | | .17 | .00002 | 75 | 26 | | .18 | |
| | IMP10-SLEQ | .14 | | .18 | .00001 | 62 | 21 | | .17 | |
| | IMPWM-SLEQ | .14 | | .18 | .00001 | 77 | 22 | | .16 | |
| | IMPWM-E90 | .14 | | .17 | .00002 | 82 | 27 | | .17 | |
| | IMP10 | .14 | | .17 | | 67 | 22 | | .17 | |
| | IMPWM | .13 | | .17 | | 64 | 23 | | .16 | |
| GNIND WND | IMP10-SLEQ | .13 | | .17 | .0001 | 47 | 21 | .0009 | .13 | |
| | IMPWM-SLEQ | .13 | | .15 | .0001 | 65 | 22 | .0001 | .13 | |
| | IMP10-E90 | .12 | | .13 | .0006 | 57 | 26 | .0004 | .13 | .0002 |
| | IMPWM-E90 | .11 | | .13 | .0006 | 76 | 27 | .0001 | .12 | .0004 |
| | IMP10 | .09 | .004 | .11 | .004 | 71 | 22 | .0001 | .09 | .006 |
| | IMPWM | .08 | .008 | .11 | .003 | 69 | 23 | | | |

TABLE OF CORRELATION COEFFICIENTS - PART 11

(Based on Individual Responses)

| Dependent Variable | Independent Variable | Kendal Non. Par. | Sig. Level | Pearson | Sig. Level | Raw $\chi^2$ | Deg. of Freedom | Sig. Level | $\tau_c$ | Sig. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| ININD | IMP10-E90 | .17 | .001 | .18 | .00001 | 101 | 26 | .0001 | .20 | .0001 |
| | IMP10-SLEQ | .17 | | .21 | | 73 | 21 | | .20 | |
| | IMPWM-SLEQ | .16 | | .21 | | 83 | 22 | | .20 | |
| | IMPWM-E90 | .16 | | .18 | | 77 | 27 | | .19 | |
| | IMP10 | .08 | .007 | .09 | .01 | 62 | 22 | | .10 | .012 |
| | IMPWM | .08 | .009 | .11 | .003 | 71 | 23 | | .10 | .009 |
| OUTJND | IMP10-SLEQ | .16 | .001 | .20 | .00001 | 63 | 21 | .0001 | .17 | .0001 |
| | IMPWM-SLEQ | .16 | | .19 | | 71 | 22 | | .17 | |
| | IMP10-E90 | .16 | | .18 | | 85 | 26 | | .17 | |
| | IMPWM-E90 | .15 | | .17 | | 94 | 24 | | .16 | |
| | IMP10 | .11 | | .12 | .001 | 66 | 22 | | .1 | .002 |
| | IMPWM | .10 | .002 | .14 | .0003 | 85 | 23 | | .1 | .002 |
| SLIND | IMP10-SLEQ | .14 | .001 | .17 | .00001 | 52 | 21 | .0002 | .12 | .0001 |
| | IMPWM-Sleq | .14 | | .17 | | 62 | 22 | .0001 | .12 | |
| | IMP10-E90 | .14 | | .16 | .00002 | 72 | 26 | .0001 | .12 | |
| | IMPWM-E90 | .14 | | .17 | | 59 | 27 | .0003 | .12 | |
| | IMPWM | .09 | .006 | .12 | .001 | 54 | 23 | .0003 | .08 | .006 |
| | IMP10 | .09 | .007 | .09 | .01 | 40 | 22 | .0095 | .06 | .02 |

TABLE 5 (CONT'D.)

## TABLE OF CORRELATION COEFFICIENTS - PART II

(Based on Individual Responses)

| Dependent Variable | Independent Variable | Kendal Non. Par. | Sig. Level | Pearson | Sig. Level | Raw $\chi^2$ | Deg. of Freedom | Sig. Level | $\tau_c$ | Sig. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| SLINDWND | IMP10-SLEQ | .06 | .05 | .08 | .031 | 38 | 21 | .01 | .04 | .05 |
| | IMPWM-SLEQ | .06 | .05 | .07 | .033 | 43 | 22 | .002 | .04 | .05 |
| | IMP10-E90 | .05 | .067 | .06 | .073 | 43 | 26 | .016 | .03 | .07 |
| | IMPWM-E90 | .05 | .085 | .06 | .075 | 51 | 27 | .003 | .03 | .08 |
| | IMP10 | .02 | .294 | .01 | .42 | 38 | 22 | .015 | .01 | .39 |
| | IMPWM | .01 | .334 | .02 | .34 | 44 | 23 | .006 | .01 | .33 |
| NUMBIND | IMP10-SLEQ | .22 | .001 | .24 | .00001 | 275 | 147 | .0001 | .19 | .0001 |
| | IMPWM-SLEQ | .22 | | .25 | | 301 | 154 | | .2 | |
| | IMP10-E90 | .22 | | .22 | | 312 | 182 | | .2 | |
| | IMPWM-E90 | .22 | | .22 | | 343 | 189 | | .19 | |
| | IMPWM | .16 | | .18 | | 340 | 161 | | .14 | |
| | IMP10 | .16 | | .16 | .00005 | 307 | 154 | | .14 | |

TABLE 5 (CONT'D.)

## TABLE OF CORRELATION COEFFICIENTS - PART II

(Based on Individual Responses)

| Dependent Variable | Independent Variable | Kendal Non. Par. | Sig. Level | Pearson | Sig. Level | Raw $\chi^2$ | Deg. of Freedom | Sig. Level | $\tau_c$ | Sig. Level |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Correlation of Responses to Traffic Noise | | | | | | | | |
| VOLTR | SLEQ | .05 | .083 | .08 | .026 | 32 | 19 | .028 | .02 | .083 |
| GNTR | | .12 | .001 | .17 | .00001 | 72 | 19 | .0001 | .15 | .0002 |
| GNTRWND | | .13 | | .18 | | 81 | 19 | | .12 | .0001 |
| INTR | | .14 | | .18 | | 80 | 19 | | .15 | " |
| OUTR | | .13 | | .18 | | 84 | 19 | | .13 | " |
| SLTR | | .12 | | .16 | | 59 | 19 | | .09 | .0003 |
| SLTRWND | | .13 | | .14 | | 66 | 19 | | .062 | .0001 |
| NUMBTR | | .16 | | .24 | | 312 | 133 | | .12 | |

TABLE 6

TABLE OF BIVARIATE REGRESSION COEFFICIENTS
REGRESSION USING INDIVIDUAL RESPONSES

Dependent Variable: Disturbed in general by noise from industry (NSANY 1)

| Independent Variable | Corr. Coef. (Pearson) | Sig. Level | Intercept | Slope |
|---|---|---|---|---|
| IMPWM - SLEQ | .31 | .00001 | .424 | .02472 |
| IMP10 - SLEQ | .31 | | .364 | .02485 |
| IMPWM - E50 | .30 | | .242 | .02436 |
| IMP10 - E50 | .29 | | .177 | .02483 |
| IMPWM - E90 | .28 | | .179 | .02310 |
| IMPWM - D90 | .28 | | .181 | .02486 |
| IMP10 - E90 | .27 | | .123 | .02309 |
| IMP10 - D90 | .27 | | .119 | .02497 |
| IMPWM - D50 | .27 | | .283 | .02445 |
| IMP10 - D50 | .26 | | .219 | .02486 |
| IMPWM - NLEQ | .26 | | .333 | .02388 |
| IMPWM - DLEQ | .26 | | .502 | .02421 |
| IMPWM - N50 | .25 | | .177 | .02103 |
| IMPWM - L50 | .25 | | .258 | .02311 |
| IMPWM - LLEQ | .25 | | .463 | .02147 |
| IMP10 - NLEQ | .25 | | .270 | .02444 |
| IMP10 - DLEQ | .25 | | .443 | .02462 |
| IMP10 - N50 | .24 | | .119 | .02150 |
| IMP10 - LLEQ | .24 | | .411 | .02135 |
| IMP10 - L50 | .24 | | .203 | .02297 |
| IMPWM - ELEQ | .24 | | .406 | .02352 |
| IMP10 - ELEQ | .24 | | .348 | .02357 |
| IMPWM - N90 | .23 | | .155 | .01999 |
| IMP10 - N90 | .23 | | .105 | .02009 |
| IMPWM | .22 | | - .648 | .01871 |

TABLE 6 (CONT'D.)

TABLE OF BIVARIATE REGRESSION COEFFICIENTS
REGRESSION USING INDIVIDUAL RESPONSES

Dependent Variable: Distrubed in general by noise from industry (NSANY 1)

| Independent Variable | Corr. Coef. (Pearson) | Sig. Level | Intercept | Slope |
|---|---|---|---|---|
| IMPWM - S50 | .22 | .00001 | .332 | .02418 |
| IMP10 | .21 | | - .709 | .01896 |
| IMPWM - S90 | .20 | | .286 | .02412 |
| IMP10 - S50 | .20 | | .286 | .02233 |
| IMPWM - L90 | .19 | | .259 | .01468 |
| IMP10 - L90 | .18 | | .233 | .01407 |
| IMP10 - S90 | .17 | | .235 | .02135 |

Regression Coefficients for Traffic Noise Responses

| | | | | |
|---|---|---|---|---|
| SLEQ | .19 | .00001 | - .415 | .01390 |
| S10 | .18 | .00001 | - .373 | .01292 |
| S50 | .15 | .00014 | - .207 | .01102 |
| S90 | .13 | .0007 | - .145 | .01039 |

Dependent Variable: Disturbed in general by noise from traffic (NSANY 2)

Regression Coefficients for responses to other noise sources have not been included since the correlations were not significant (sig. level > .05)

TABLE 6 (CONT'D.)

TABLE OF BIVARIATE REGRESSION COEFFICIENTS
REGRESSION USING INDIVIDUAL RESPONSES

| Dependent Variable | Independent Variable | Corr. Coef. (Pearson) | Sig. Level | Intercept | Slope |
|---|---|---|---|---|---|
| VOLIND | IMPWM-SLEQ | .18 | .00001 | .214 | .01224 |
| | IMPWM | .17 | .00001 | - .49 | .01222 |
| | IMPWM-E90 | .17 | .00002 | .0914 | .01155 |
| | IMP10-SLEQ | .17 | .00002 | .186 | .01184 |
| | IMP10-E90 | .16 | .00006 | .0703 | .01104 |
| | IMP10 | .16 | .00006 | - .509 | .01203 |
| GNIND | IMPWM-SLEQ | .18 | .00001 | .253 | .01241 |
| | IMP10-SLEQ | .18 | .00001 | .222 | .01287 |
| | IMP10-E90 | .17 | .00002 | .088 | .01257 |
| | IMPWM-E90 | .17 | | .124 | .01212 |
| | IMP10 | .17 | | - .566 | .01363 |
| | IMPWM | .17 | | - .471 | .01257 |
| GNINDWND | IMP10-SLEQ | .16 | .0001 | .15 | .00979 |
| | IMPWM-SLEQ | .15 | .0001 | .174 | .00938 |
| | IMP10-E90 | .13 | .0006 | .0616 | .00862 |
| | IMPWM-E90 | .13 | .0006 | .0867 | .00827 |
| | IMP10 | .11 | .004 | - .282 | .00761 |
| | IMPWM | .11 | .003 | - .251 | .00740 |
| ININD | IMP10-SLEQ | .21 | .00001 | .214 | .01519 |
| | IMPWM-SLEQ | .21 | | .251 | .01468 |
| | IMP10-E90 | .18 | | .081 | .01309 |
| | IMPWM-E90 | .18 | | .118 | .01270 |
| | IMPWM | .11 | .003 | - .238 | .00859 |
| | IMP10 | .09 | .01 | - .207 | .00771 |

TABLE 6 (CONT'D.)

TABLE OF BIVARIATE REGRESSION COEFFICIENTS

REGRESSION USING INDIVIDUAL RESPONSES

| Dependent Variable | Independent Variable | Corr. Coef. (Pearson) | Sig. Level | Intercept | Slope |
|---|---|---|---|---|---|
| OUTIND | IMP10-SLEQ | .20 | .00001 | .136 | .01234 |
| | IMPWM-SLEQ | .19 | | .167 | .01177 |
| | IMP10-E90 | .18 | | .0159 | .01152 |
| | IMPWM-E90 | .17 | | .0502 | .01098 |
| | IMPWM | .14 | .0003 | - .363 | .00924 |
| | IMP10 | .12 | .001 | - .346 | .00856 |
| SLIND | IMP10-SLEQ | .17 | .00001 | .913 | .00902 |
| | IMPWM-SLEQ | .17 | .00001 | .114 | .00881 |
| | IMPWM-E90 | .17 | .00002 | .0183 | .00891 |
| | IMP10-E90 | .16 | .00002 | - .0064 | .00912 |
| | IMPWM | .12 | .001 | - .287 | .00698 |
| | IMP10 | .09 | .01 | - .221 | .00558 |
| SLINDWND | IMP10-SLEQ | .08 | .031 | .0464 | .00283 |
| | IMPWM-SLEQ | .07 | .033 | .0534 | .00271 |
| | IMP10-E90 | .06 | .073 | .0236 | .00230 |
| | IMPWM-E90 | .06 | .075 | .0304 | .00220 |
| | IMP10-10 | - .01 | .42 | .0756 | - .00035 |
| | IMPWM | .02 | .34 | .0176 | .00066 |
| NUMBIND | IMPWM-SLEQ | .25 | .00001 | 1.238 | .07329 |
| | IMP10-SLEQ | .24 | | 1.053 | .07524 |
| | IMP10-E90 | .22 | | .339 | .06887 |
| | IMPWM-E90 | .22 | | .525 | .06730 |
| | IMPWM | .18 | | -2.061 | .05753 |
| | IMP10 | .16 | .00005 | -2.034 | .05464 |

Bivariate Regression Coefficients for Traffic Noise

| | | | | | |
|---|---|---|---|---|---|
| VOLTR | SLEQ | .08 | .026 | - .0884 | .00211 |
| GNTR | | .17 | .00001 | - .386 | .01196 |
| GNTRWND | | .18 | | - .406 | .00964 |
| INTR | | .18 | | - .413 | .01143 |
| OUTR | | .18 | | - .409 | .01001 |
| SLTR | | .16 | | - .287 | .00639 |
| SLTRWND | | .14 | .0002 | - .183 | .00375 |
| NUMBTR | | .24 | .00001 | -2.355 | .05691 |

TABLE 7 Table of Bivariate Regression Coefficient - Grouped Responses

Grouped by ascending order of impulse weighted mean level (not differentiated by sites)

Independent Variable - Impulse Weighted Mean Level (dBAI WM)

Range of indep. var. - 49 to 73 dBAI

| Dependent Var. | Corr. Coeff. (r) Pearson | Sig. Level | $r^2$ | Intercept | Slope | Std. Error of Estimate of dep. var. % | Max. Value of dep. var. % | No. of Groups and No. per Group |
|---|---|---|---|---|---|---|---|---|
| NSANY 1 | .55 | .00265 | .303 | -65.4 | 1.88111 | 17.0 | 75 | 24/25 |
| | .81 | .00071 | .655 | -71.4 | 1.98316 | 9.0 | 70 | 12/50 |
| VOLIND | .59 | .00112 | .352 | -50.8 | 1.25175 | 10.2 | 50 | 24/25 |
| | .87 | .00012 | .756 | -54.3 | 1.31255 | 4.6 | 40 | 12/50 |
| GNIND | .47 | .00984 | .223 | -46.1 | 1.24041 | 13.8 | 55 | 24/25 |
| | .71 | .00451 | .511 | -53.6 | 1.36730 | 8.3 | 50 | 12/50 |
| GNINDWND | .35 | .04770 | .121 | -24.0 | .72234 | 11.6 | 45 | 24/25 |
| | .56 | .02994 | .310 | -27.1 | .77421 | 7.2 | 35 | 12/50 |
| ININD | .31 | .07049 | .096 | -22.0 | .82900 | 15.2 | 67 | 24/25 |
| | .52 | .04261 | .267 | -27.4 | .92019 | 9.5 | 40 | 12/50 |
| OUTIND | .39 | .02802 | .156 | -33.0 | .86705 | 12.1 | 50 | 24/25 |
| | .58 | .02478 | .333 | -32.8 | .86330 | 7.6 | 35 | 12/50 |
| SLIND | .39 | .02815 | .156 | -25.5 | .64254 | 9.0 | 30 | 24/25 |
| | .54 | .03457 | .293 | -28.5 | .69444 | 6.7 | 25 | 12/50 |
| SLINDWND | .09 | .33882 | .008 | 1.19 | .07519 | 5.0 | 15 | 24/25 |
| | .15 | .31853 | .023 | .05 | .09658 | 3.9 | 10 | 12/50 |

TABLE 8 Table of Bivariate Regression Coefficient - Grouped Responses

Grouped by ascending order of impulse weighted mean level within each site.
Independent variable: Impulse Weighted Mean Level (dBAI WM)

| Dependent Var. | Corr. Coeff. (r) Pearson | Sig. Level | $r^2$ | Intercept | Slope | Std. Error of Estimate of dep. var. % | Max. Value of dep. var. % | Group |
|---|---|---|---|---|---|---|---|---|
| NSANY I | .64 | .00973 | .41 | -103.0 | 2.59070 | 16.7 | 85 | PC, Welland, Windsor |
| | .83 | .00001 | .69 | -138.0 | 3.03153 | 11.7 | 75 | PC, Welland |
| | .79 | .00004 | .62 | -128.3 | 2.88855 | 13.1 | 85 | PC, Welland, Windold |
| VOLIND | .65 | .00201 | .42 | -72.0 | 1.60295 | 10.1 | 56 | PC, Welland, Windsor |
| | .74 | .00949 | .55 | -79.6 | 1.72089 | 9.1 | 56 | PC, Welland |
| | .74 | .00021 | .55 | -81.6 | 1.74425 | 9.3 | 52 | PC, Welland, Windold |
| GNIND | .59 | .01745 | .35 | -80.4 | 1.81029 | 13.5 | 60 | PC, Welland, Windsor |
| | .76 | .00001 | .58 | -99.6 | 2.08604 | 10.2 | 56 | PC, Welland |
| | .75 | .00015 | .56 | -96.9 | 2.05260 | 10.5 | 56 | PC, Welland, Windold |
| GNINDWND | .55 | .05446 | .30 | -49.6 | 1.14815 | 9.6 | 48 | PC, Welland, Windsor |
| | .83 | .00002 | .69 | -67.0 | 1.40154 | 5.4 | 35 | PC, Welland |
| | .80 | .00003 | .64 | -63.4 | 1.35076 | 5.9 | 32 | PC, Welland, Windold |
| ININD | .47 | .09675 | .22 | -59.9 | 1.45772 | 14.7 | 72 | PC, Welland, Windsor |
| | .76 | .00004 | .58 | -82.5 | 1.78910 | 8.9 | 56 | PC, Welland |
| | .76 | .00014 | .58 | -81.2 | 1.77195 | 9.0 | 60 | PC, Welland Windold |

cont'd.

TABLE 8 (CONT'D.) Table of Bivariate Regression Coefficient - Grouped Responses

| Dependent Vari. | Corr. Coeff. (r) Pearson | Sig. Level | $r^2$ | Intercept | Slope | Std. Error of Estimate of dep. var. % | Max. Value of dep. var. % | Group |
|---|---|---|---|---|---|---|---|---|
| OUTIND | .53 | .01374 | .28 | -52.2 | 1.18228 | 10.4 | 40 | PC, Welland, Windsor |
| | .76 | .00003 | .58 | -68.8 | 1.42785 | 7.0 | 40 | PC, Welland |
| | .75 | .00016 | .56 | -66.3 | 1.39008 | 7.2 | 40 | PC, Welland, Windold |
| SLIND | .57 | .02268 | .32 | -45.0 | .96957 | 7.5 | 30 | PC, Welland, Windsor |
| | .74 | .00011 | .55 | -56.8 | 1.14616 | 6.1 | 28 | PC, Welland |
| | .69 | .00072 | .48 | -56.2 | 1.08216 | 6.6 | 28 | PC, Welland, Windold |
| SLINDWND | .2 | .41623 | .04 | -5.18 | .18119 | 4.9 | 18 | PC, Welland Windsor |
| | .31 | .05488 | .1 | -10.7 | .26386 | 4.6 | 12 | PC, Welland |
| | .29 | .12199 | .08 | - 9.4 | -- | 4.7 | 10 | PC, Welland, Windold |

TABLE 9

Table of Bivariate Regression Coefficient - Grouped Responses

Grouped in ascending order of the difference between the impulse weighted mean level and the evening $L_{90}$ within each site

Independent Variable: Impulse Weighted Mean Level - Evening $L_{90}$ (IMPWME90), Range 6-22

| Dependent Vari. | Corr. Coeff. (r) Pearson | Sig. Level | $r^2$ | Intercept | Slope | Std. Error of Estimate of dep. var. % | Max. Value of dep. var. % | Group |
|---|---|---|---|---|---|---|---|---|
| NSANY 1 | .64 | .0016 | .409 | 17.0 | 2.37531 | 18.1 | 85 | All sites |
| | .75 | .0004 | .564 | 11.8 | 2.71150 | 15.2 | 80 | PC, Welland. |
| VOLIND | .61 | .0027 | .373 | 8.6 | 1.19941 | 9.9 | 40 | All sites |
| | .70 | .0012 | .495 | 5.9 | 1.48954 | 9.6 | 40 | PC, Welland. |
| GNIND | .51 | .012 | .264 | 11.9 | 1.24437 | 13.2 | 55 | All sites |
| | .56 | .012 | .316 | 9.7 | 1.28460 | 12.0 | 45 | PC, Welland. |
| GNINDWND | .47 | .022 | .218 | 7.9 | .88885 | 10.7 | 45 | All sites |
| | .56 | .012 | .316 | 5.7 | .93361 | 8.7 | 30 | PC, Welland |
| ININD | .48 | .018 | .234 | 11.3 | 1.29949 | 14.9 | 65 | All sites |
| | .66 | .0028 | .434 | 7.2 | 1.48392 | 10.8 | 50 | PC, Welland |
| OUTIND | .55 | .0074 | .302 | 5.3 | 1.06364 | 10.3 | 40 | All sites |
| | .62 | .0054 | .384 | 3.2 | 1.13717 | 9.2 | 40 | PC, Welland |
| SLIND | .56 | .0061 | .317 | 1.96 | .87973 | 8.2 | 30 | All sites |
| | .68 | .002 | .459 | - .36 | 1.03887 | 7.2 | 30 | PC, Welland |
| SLINDWND | .21 | .19 | .045 | 3.5 | .18004 | 5.3 | 20 | All sites |
| | .34 | .099 | .115 | 2.2 | .25700 | 4.5 | 12 | PC, Welland |

TABLE 10

## Table of Bivariate Regression Coefficient - Grouped Responses

Grouped in ascending order of the difference between the Impulse Weighted Mean Level and the spot $L_{eq}$ within each site.

Independent Variable : Impulse Weighted Mean Level - Spot $L_{eq}$ (IMPWMSLQ), Range: -10 to +10.

| Dependent Var . | Corr. Coeff. (r) Pearson | Sig. Level | $r^2$ | Intercept | Slope | Std. Error of Estimate of dep. var. % | Max. Value of dep. var. % | Group |
|---|---|---|---|---|---|---|---|---|
| NSANY 1 | .69 | .00078 | .475 | 41.8 | 2.71004 | 16.4 | 85 | All sites |
| | .67 | .003 | .446 | 40.9 | 2.53084 | 16.7 | 80 | PC, Welland |
| VOLIND | .50 | .018 | .247 | 21.4 | 1.18501 | 11.9 | 42 | All sites |
| | .53 | .020 | .285 | 2712 | 1.27270 | 11.9 | 42 | PC, Welland |
| GNIND | .45 | .030 | .205 | 24.8 | 1.30531 | 14.8 | 58 | All sites |
| | .37 | .085 | .139 | 23.6 | .99226 | 14.6 | 50 | PC, Welland |
| GNINDWND | .51 | .015 | .263 | 16.7 | 1.11585 | 10.7 | 45 | All sites |
| | .42 | .06 | .176 | 15.7 | .76323 | 9.8 | 32 | PC, Welland |
| ININD | .47 | .025 | .22 | 25.0 | 1.41368 | 15.3 | 72 | All sites |
| | .45 | .045 | .205 | 23.8 | 1.08140 | 12.6 | 45 | PC, Welland |
| OUTIND | .49 | .019 | .24 | 16.2 | 1.15721 | 11.7 | 45 | All sites |
| | .41 | .063 | .17 | 15.6 | .84772 | 11.1 | 40 | PC, Welland |
| SLIND | .61 | .00341 | .376 | 11.0 | 1.02308 | 7.6 | 35 | All sites |
| | .55 | .017 | .303 | 10.8 | .87443 | 7.8 | 35 | PC, Welland |
| SLINDWND | .29 | .12 | .083 | 5.3 | .29808 | 5.7 | 18 | All sites |
| | .2 | .24 | .039 | 5.1 | .20042 | 5.9 | 18 | PC, Welland |

TABLE 11 Table of Bivariate Regression Coefficient - Grouped Responses (Traffic noise)

Grouped by ascending order of spot $L_{eq}$ within each site.

Independent Variable: Spot $L_{eq}$ (dB) Range 45 - 72 dBA

| Dependent Var . | Corr. Coeff. (r) Pearson | Sig. Level | $r^2$ | Intercept | Slope | Std. Error of Estimate of dep. var. % | Max. Value of dep. var. % | Group |
|---|---|---|---|---|---|---|---|---|
| NSANY 2 | .59 | .0038 | .351 | -43.4 | 1.42183 | 13.5 | 70 | All sites |
| | .55 | .014 | .299 | -46.5 | 1.47076 | 14.8 | 70 | PC, Welland |
| VOLTR | .37 | .06 | .136 | -8.6 | .20671 | 3.6 | 12 | All sites |
| | .43 | .048 | .184 | -11.5 | .24799 | 3.4 | 12 | PC, Welland |
| GNTR | .60 | .003 | .357 | -40.3 | 1.22561 | 11.5 | 50 | All sites |
| | .55 | .013 | .308 | -43.1 | 1.26687 | 12.5 | 50 | PC, Welland |
| GNTRWND | .57 | .0053 | .326 | -41.2 | .97560 | 9.8 | 35 | All sites |
| | .49 | .026 | .243 | -36.1 | .89205 | 10.4 | 35 | PC, Welland |
| INTR | .52 | .012 | .268 | -44.8 | 1.20077 | 13.8 | 50 | All sites |
| | .47 | .032 | .225 | -44.6 | 1.20908 | 14.8 | 50 | PC, Welland |
| OUTTR | .58 | .0044 | .339 | -42.5 | 1.02800 | 10.0 | 40 | All sites |
| | .58 | .0093 | .336 | -50.8 | 1.16521 | 10.8 | 40 | PC, Welland |
| SLTR | .61 | .0028 | .373 | -29.3 | .64801 | 5.9 | 25 | All sites |
| | .54 | .014 | .298 | -28.5 | .63696 | 6.4 | 25 | PC, Welland |
| SLTRWND | .44 | .030 | .192 | -19.2 | .39075 | 5.6 | 18 | All sites |
| | .40 | .064 | .157 | -19.7 | .39997 | 6.1 | 18 | PC, Welland |

TABLE 12

Independent variable
IMPWM

## TABLE OF BIVARIATE REGRESSION COEFFICIENTS - GROUPED RESPONSES

## GEOGRAPHICALLY GROUPED

| Dep. Var. | Corr. Coef. Pearson (r) | Sig. level | $r^2$ | Intercept | Slope | Std. error of est. of dep. var. | Max. value of dep. var. % | Range of Indep. Var. | | Group |
|---|---|---|---|---|---|---|---|---|---|---|
| NSANY 1 | .63 | .0019 | .398 | - 130.3 | 2.96988 | 19.8 | 85 | 49 | 70 | all sites |
| | .76 | .00013 | .577 | - 154.2 | 3.328 | 15.7 | 81 | | | excluding WINDNEW |
| | .79 | .00014 | .622 | - 162.56 | 3.4428 | 15.7 | 81 | | | Welland, PC |
| | .84 | .00008 | .710 | - 178.03 | 3.67 | 14.47 | 81 | | | Welland |
| VOLIND | .62 | .0021 | .391 | - 102.6 | 2.12338 | 14.4 | 48 | | | all sites |
| | .689 | .00079 | .474 | - 114.3 | 2.29852 | 13.4 | 53 | | | excluding WINDNEW |
| | .685 | .0017 | .469 | - 112.3 | 2.27 | 14.2 | 53 | | | Welland, PC |
| | .73 | .00139 | .539 | - 123.1 | 2.43080 | 13.8 | 52 | | | Welland |
| GNIND | .64 | .0016 | .407 | - 90.8 | 1.98728 | 13.0 | 58 | | | all sites |
| | .84 | .00008 | .707 | - 112.1 | 2.29649 | 9.1 | 49 | | | Welland |
| GNINDWND | .56 | .0063 | .314 | - 60.2 | 1.32763 | 10.6 | 47 | | | all sites |
| | .82 | .00016 | .674 | - 80.8 | 1.62722 | 6.98 | 35 | | | Welland |
| ININD | .50 | .01439 | .251 | - 74.5 | 1.70829 | 15.97 | 72 | | | all sites |
| | .81 | .00022 | .656 | - 110.1 | 2.24109 | 10.01 | 62 | | | Welland |
| OUTIND | .53 | .00961 | .282 | - 61.36 | 1.33935 | 11.56 | 54 | | | all sites |
| | .76 | .00072 | .585 | - 84.6 | 1.68387 | 8.74 | 53 | | | Welland |
| SLIND | .58 | .00471 | .335 | - 51.2 | 1.07546 | 8.21 | 27 | | | all sites |
| | .85 | .00006 | .725 | - 69.6 | 1.34242 | 5.1 | 26 | | | Welland |
| SLINDWND | .33 | .08433 | .108 | - 16.0 | .36578 | 5.7 | 20 | | | all sites |
| | .52 | .02748 | .274 | - 26.1 | .51373 | 5.2 | 19 | | | Welland |
| MOTH I | .64 | .00156 | .41 | - 104.2 | 2.29394 | 14.89 | 70 | | | all sites |
| | .86 | .00005 | .73 | - 137.5 | 2.78697 | 10.35 | 70 | | | Welland |

TABLE 13

Independent variable
IMPWM - SLEQ

## TABLE OF BIVARIATE REGRESSION COEFFICIENTS - GROUPED RESPONSES

### GEOGRAPHICALLY GROUPED

| Dep. Var. | Corr. Coef. Pearson(r) | Sig. level | $r^2$ | Intercept | Slope | Std. error of est. of dep. var. | Max. value of dep. var. % | Range of Indep. Var. Min. | Max. | Group |
|---|---|---|---|---|---|---|---|---|---|---|
| NSANY 1 | .70 | .0004 | .488 | 41.7 | 3.01296 | 18.2 | 85 | - 11 | 14 | all sites |
| | .67 | .0013 | .449 | 40.8 | 2.75381 | 18.0 | 81 | - 11 | 14 | excluding WINDNEW |
| | .67 | .0023 | .447 | 41.1 | 2.80766 | 19.0 | 81 | - 11 | 12 | Welland, PC |
| | .87 | .00003 | .749 | 46.9 | 4.65770 | 13.47 | 82 | - 11 | 7 | Welland |
| VOLIND | .52 | .011 | .272 | 20.9 | 1.62338 | 15.7 | 48 | - 11 | 14 | all sites |
| | .49 | .019 | .239 | 20.59 | 1.53766 | 16.1 | 53 | - 11 | 14 | excluding WINDNEW |
| | .54 | .016 | .289 | 22.03 | 1.71500 | 16.4 | 53 | - 11 | 12 | Welland, PC |
| | .68 | .0035 | .468 | 25.40 | 2.79404 | 14.9 | 52 | - 11 | 7 | Welland |
| GNIND | .55 | .0077 | .299 | 24.7 | 1.55978 | 14.1 | 58 | - 11 | 14 | all sites |
| | .81 | .0002 | .661 | 28.3 | 2.74016 | 9.8 | 49 | - 11 | 7 | Welland |
| GNINDWND | .56 | .0058 | .320 | 16.8 | 1.22887 | 10.6 | 47 | - 11 | 14 | all sites |
| | .76 | .00089 | .571 | 18.6 | 1.84857 | 8.0 | 36 | - 11 | 7 | Welland |
| ININD | .59 | .00366 | .359 | 24.29 | 1.85445 | 14.8 | 72 | - 11 | 14 | all sites |
| | .77 | .00058 | .599 | 26.8 | 2.64353 | 10.8 | 62 | - 11 | 7 | Welland |
| OUTIND | .51 | .01322 | .257 | 16.4 | 1.17261 | 11.8 | 53 | - 11 | 14 | all sites |
| | .62 | .00951 | .379 | 17.9 | 1.67525 | 10.7 | 53 | - 11 | 7 | Welland |
| SLIND | .66 | .00095 | .442 | 11.1 | 1.13133 | 7.5 | 27 | - 11 | 14 | all sites |
| | .79 | .00041 | .620 | 12.4 | 1.53257 | 6.0 | 26 | - 11 | 7 | Welland |
| SLINDWND | .52 | .01141 | .269 | 5.0 | .52804 | 5.1 | 20 | - 11 | 14 | all sites |
| | .48 | .04268 | .227 | 5.2 | .57711 | 5.33 | 19 | - 11 | 7 | Welland |
| MOTH 1 | .61 | .00268 | .37 | 28.9 | 2.00748 | 15.34 | 70 | - 11 | 14 | all sites |
| | .78 | .00047 | .61 | 32.6 | 3.14196 | 12.49 | 70 | - 11 | 7 | Welland |

TABLE 14

TABLE OF BIVARIATE REGRESSION COEFFICIENTS - GROUPED RESPONSES

Independent Variable: LDIST

GEOGRAPHICALLY GROUPED

| Dep. Var. | Sig. Level | Corr. Coef. (r) Pearson | $r^2$ | Intercept | Slope | Std. error of est. of dep. var. | Max. value of dep. var. % | Range of Indep. var. Max. | Range of Indep. var. Min. | Group |
|---|---|---|---|---|---|---|---|---|---|---|
| NSANY 1 | .0026 | - .61 | .378 | 224.3 | - 59.1 | 20.1 | 85 | 3.5 | 2.5 | all sites |
| NSANY 1 | .0001 | - .87 | .758 | 296.1 | - 84.98 | 12.6 | 80 | | | Welland, PC |
| VOLIND | .00051 | - .69 | .479 | 168.5 | - 48.0 | 13.3 | 50 | | | all sites |
| GNIND | .0029 | - .61 | .369 | 143.8 | - 38.7 | 13.4 | 60 | | | all sites |
| ININD | .013 | - .51 | .259 | 133.8 | - 35.4 | 15.9 | 70 | | | all sites |
| MOTH 1 | .0015 | - .64 | .412 | 173.7 | - 46.97 | 14.9 | 65 | | | all sites |
| | .00001 | - .904 | .817 | 223.3 | - 65.007 | 8.07 | 65 | | | Welland. PC |

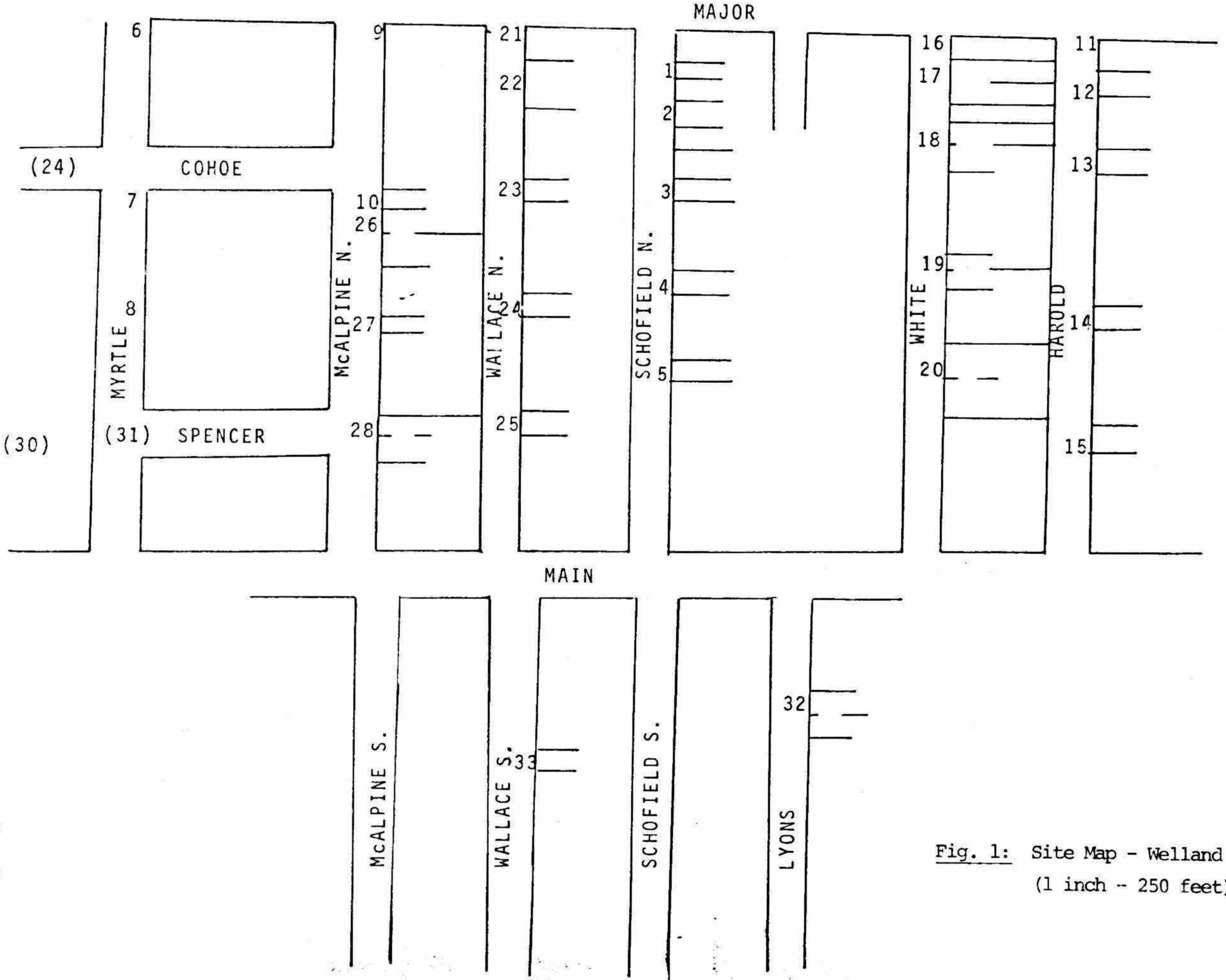



Fig. 1: Site Map - Welland
(1 inch - 250 feet)

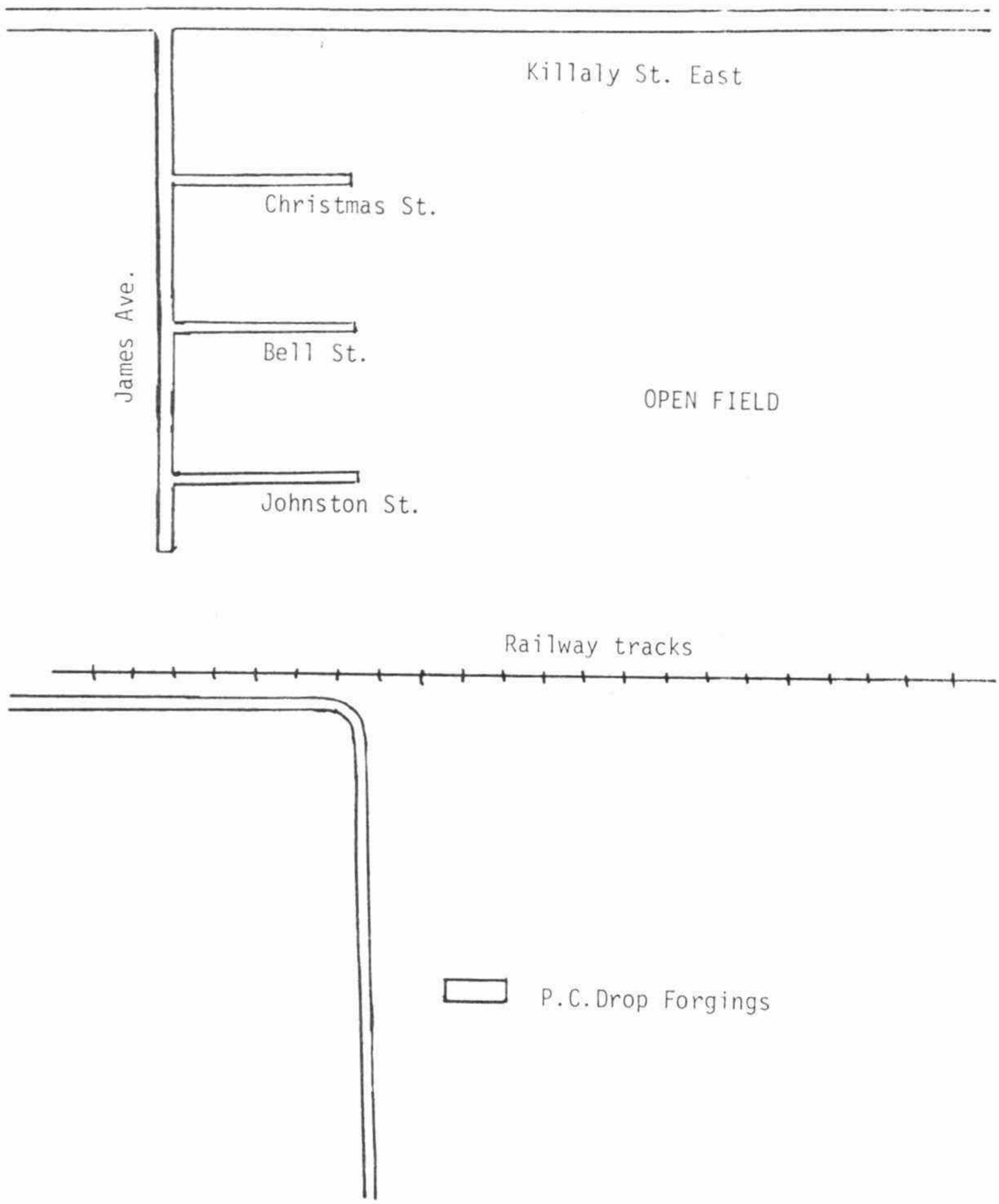



Fig. 2: Site map - Port Colborne
(1 inch - 400 feet)

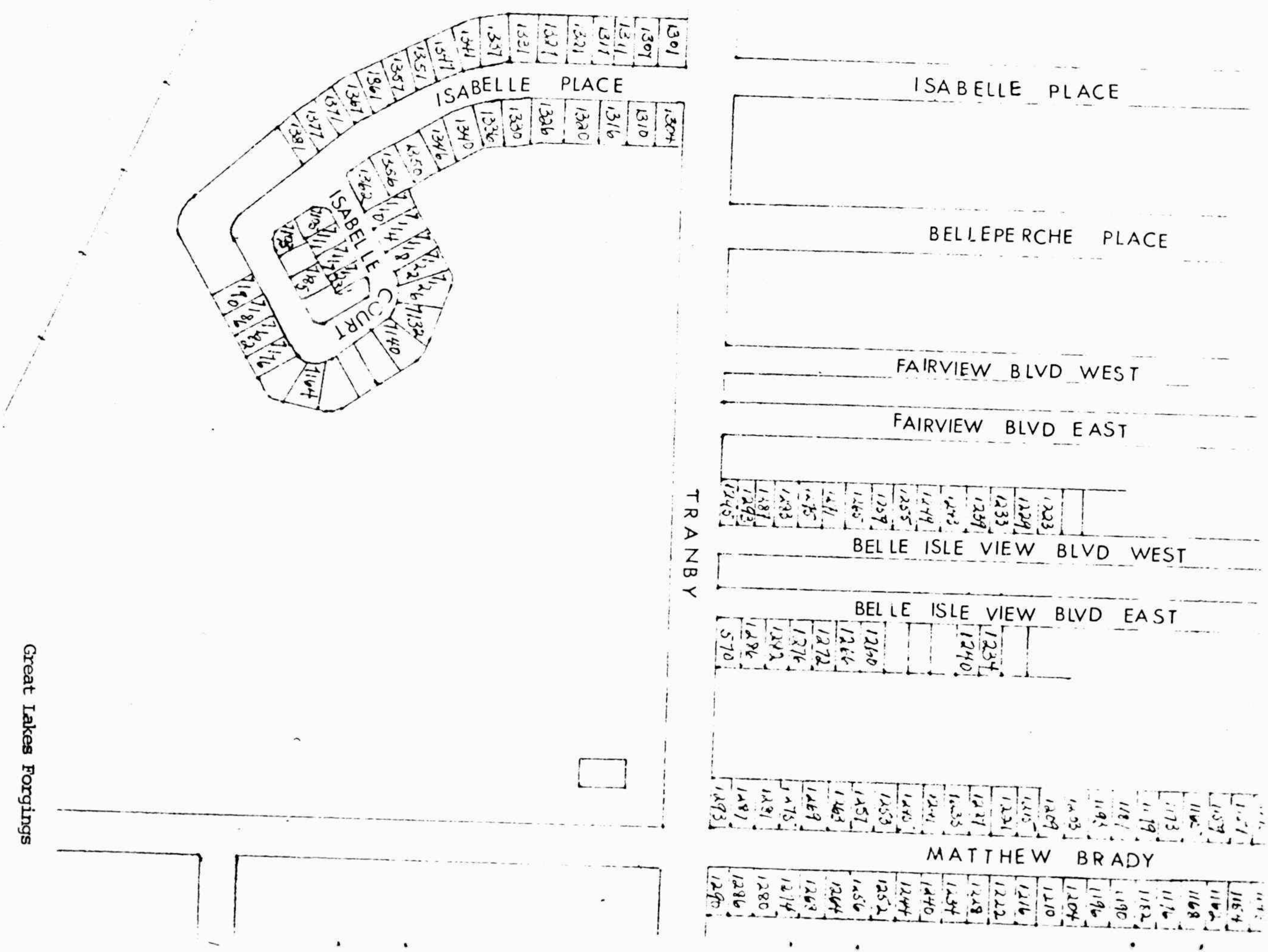



Fig.3: Site map - Windsor
(1 inch - 250 feet)


FIGURE 4 : OBSERVATIONAL DATA

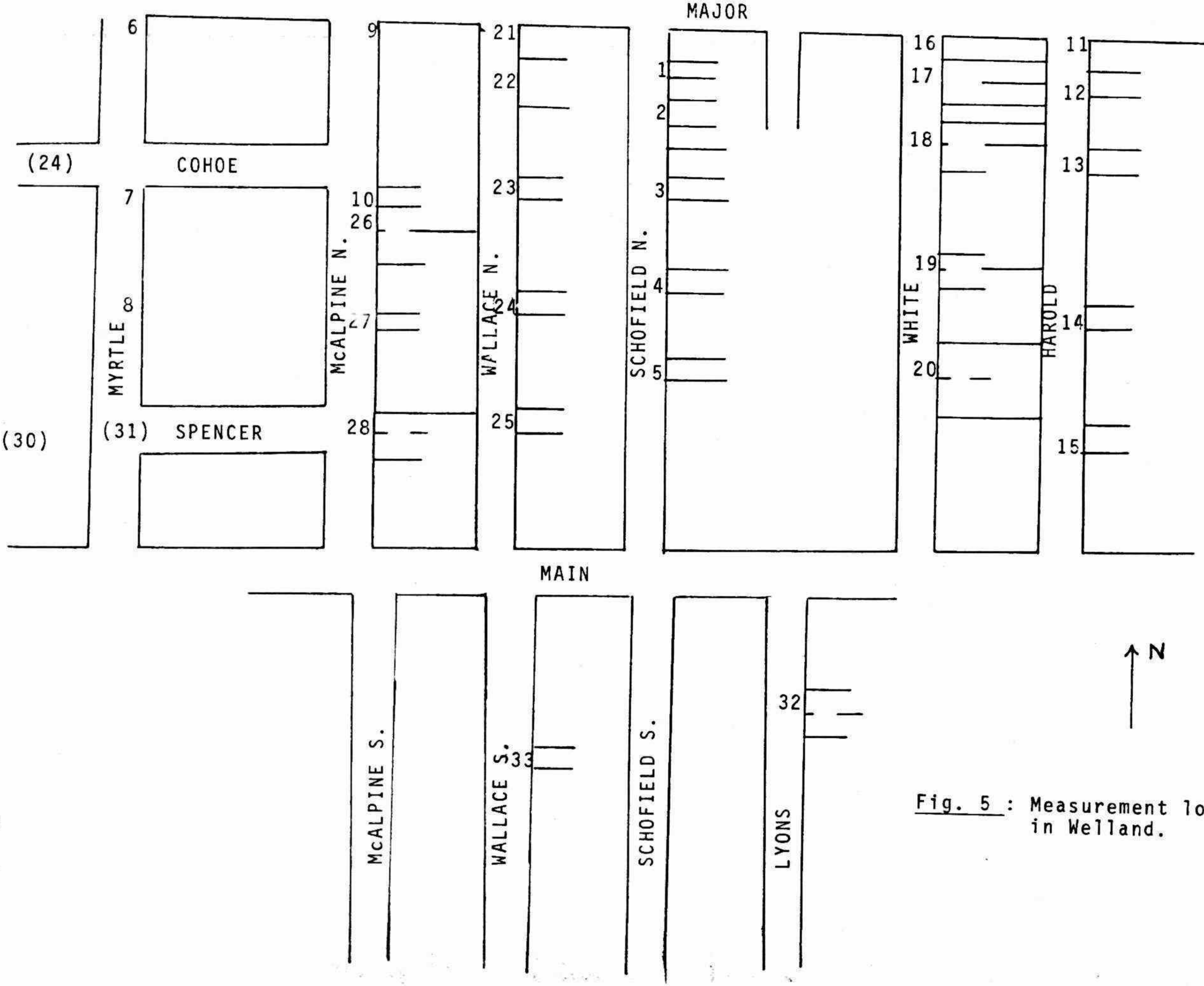



Fig. 5 : Measurement locations in Welland.

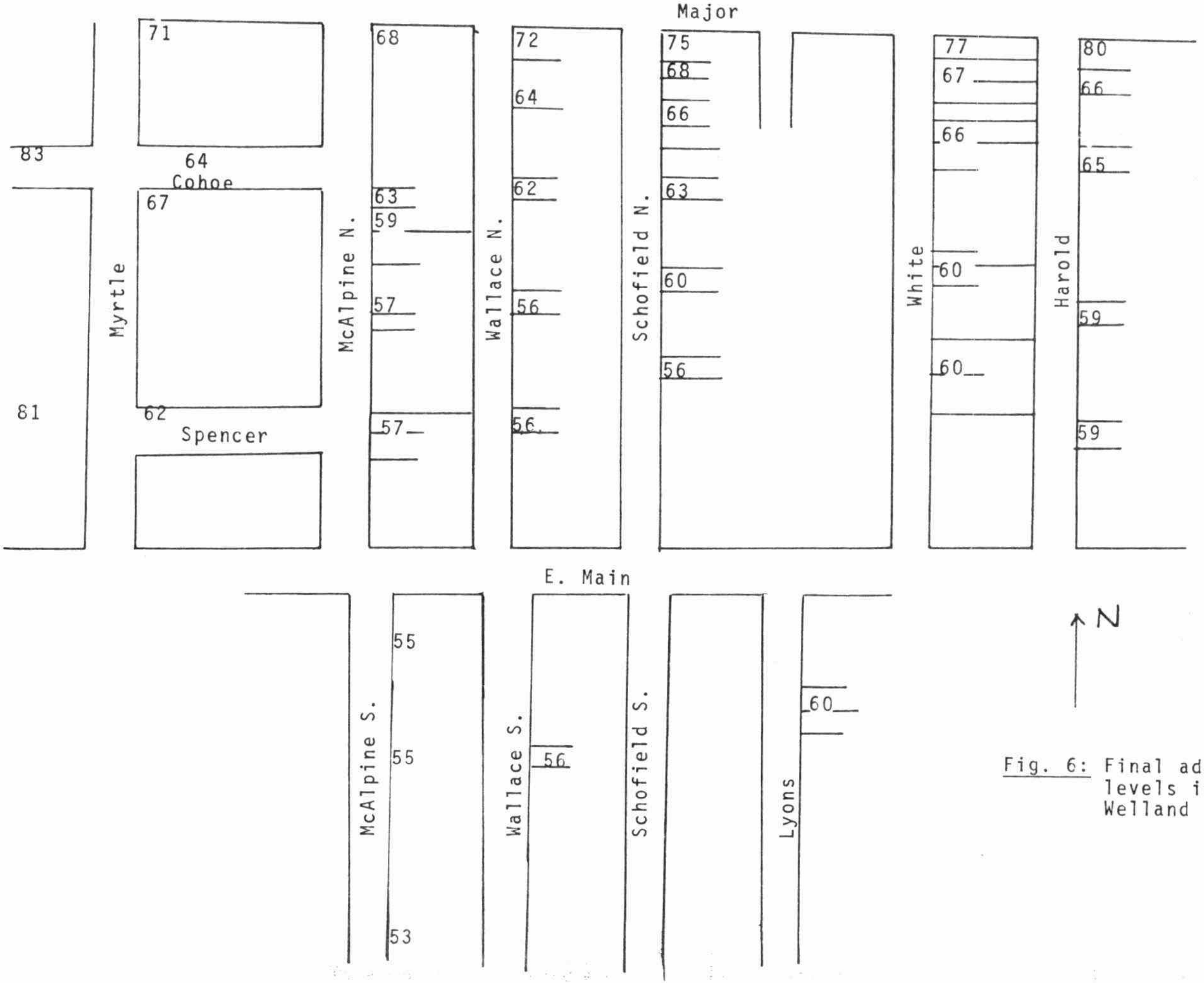



Fig. 6: Final adjusted levels in Welland (dBAI WM)

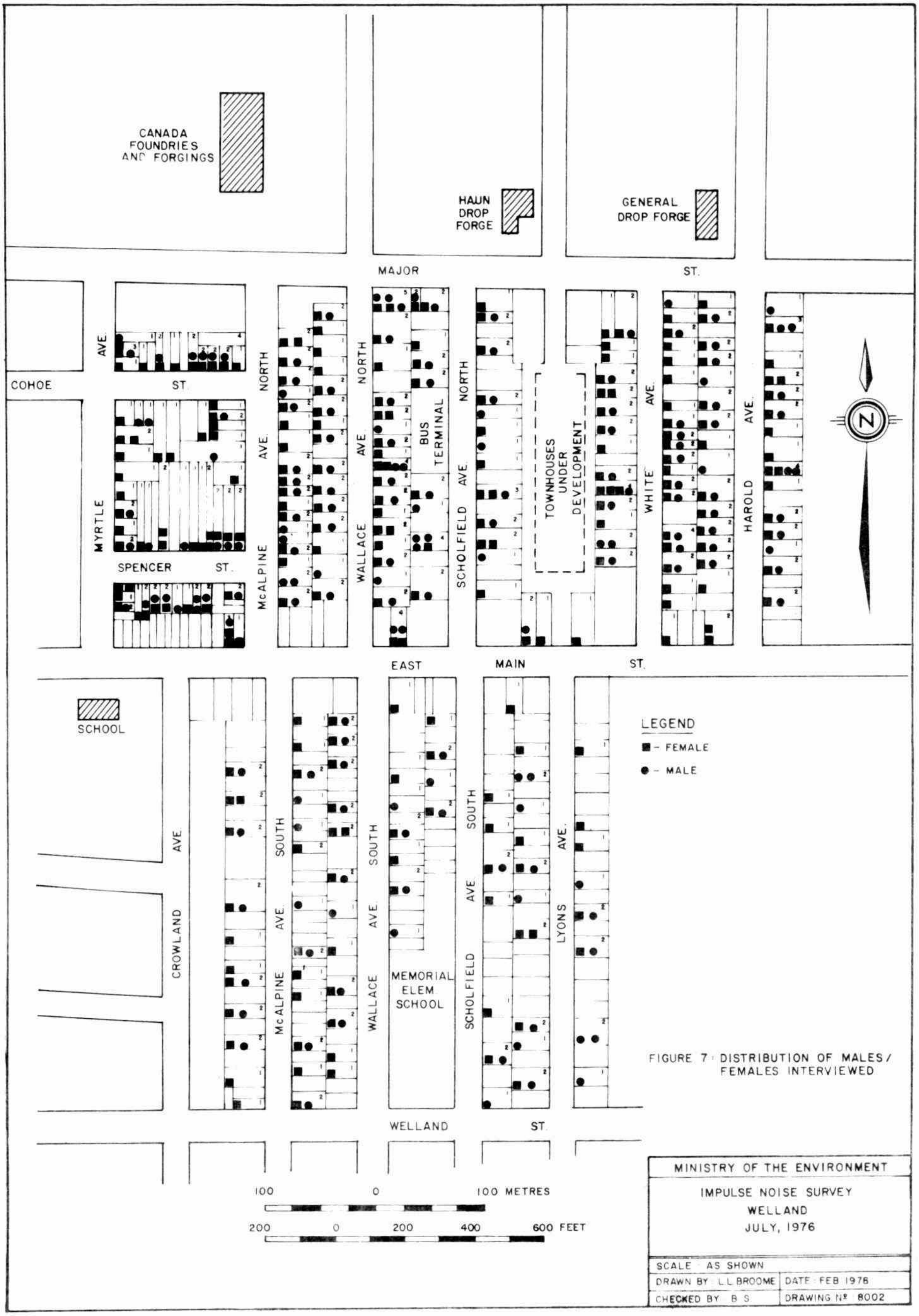



FIGURE 7: DISTRIBUTION OF MALES/ FEMALES INTERVIEWED

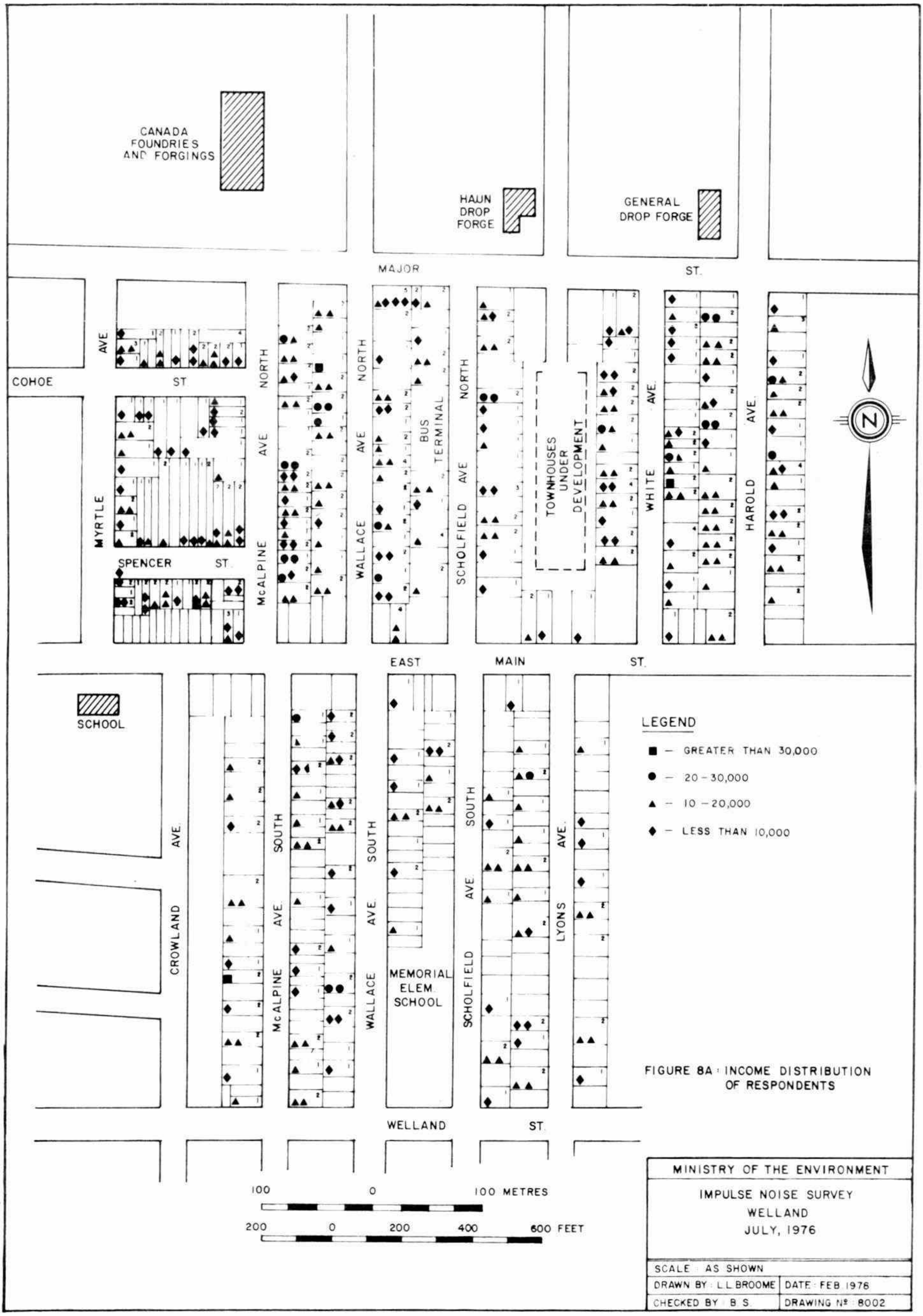



FIGURE 8A: INCOME DISTRIBUTION OF RESPONDENTS

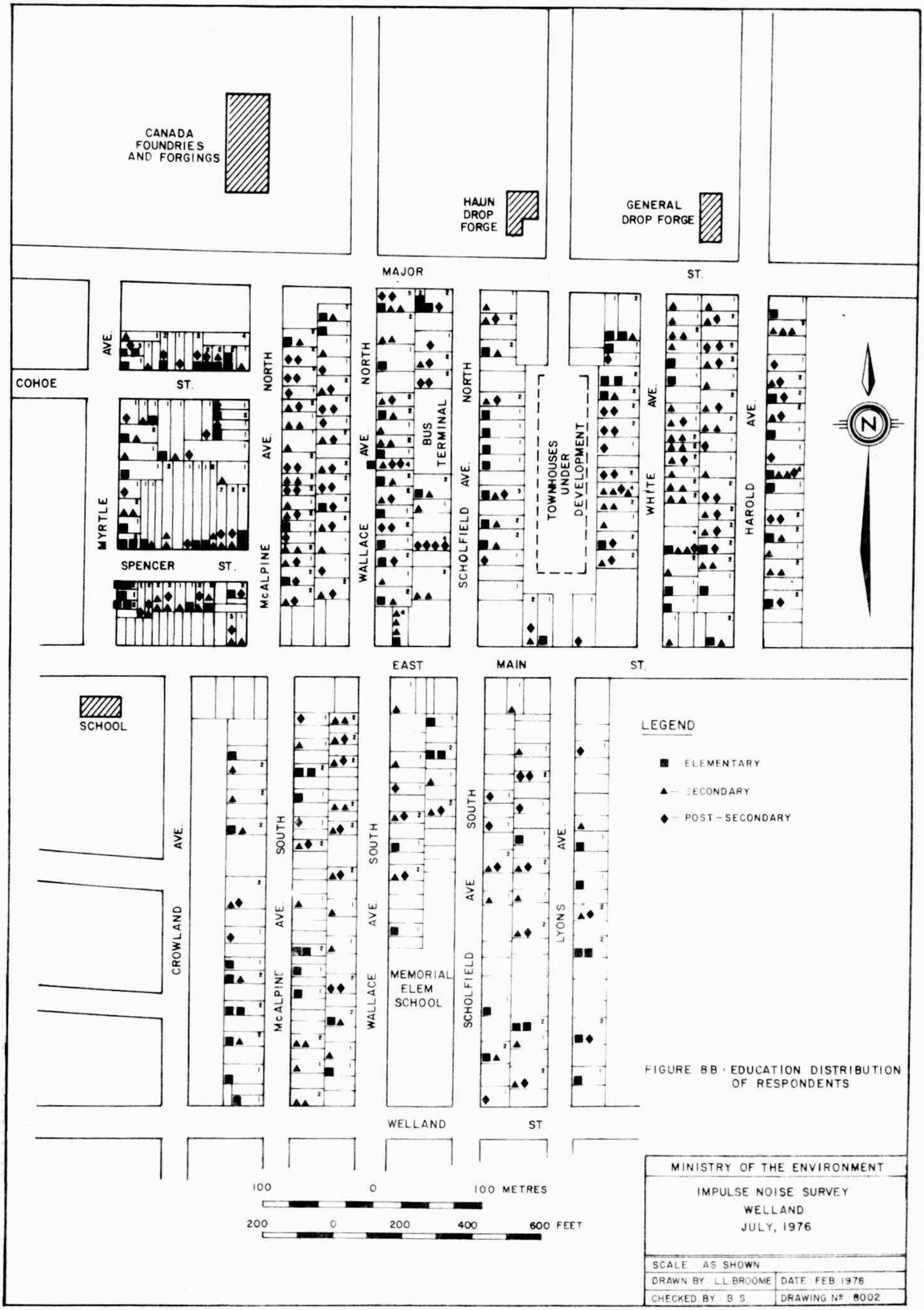


FIGURE 8B · EDUCATION DISTRIBUTION OF RESPONDENTS

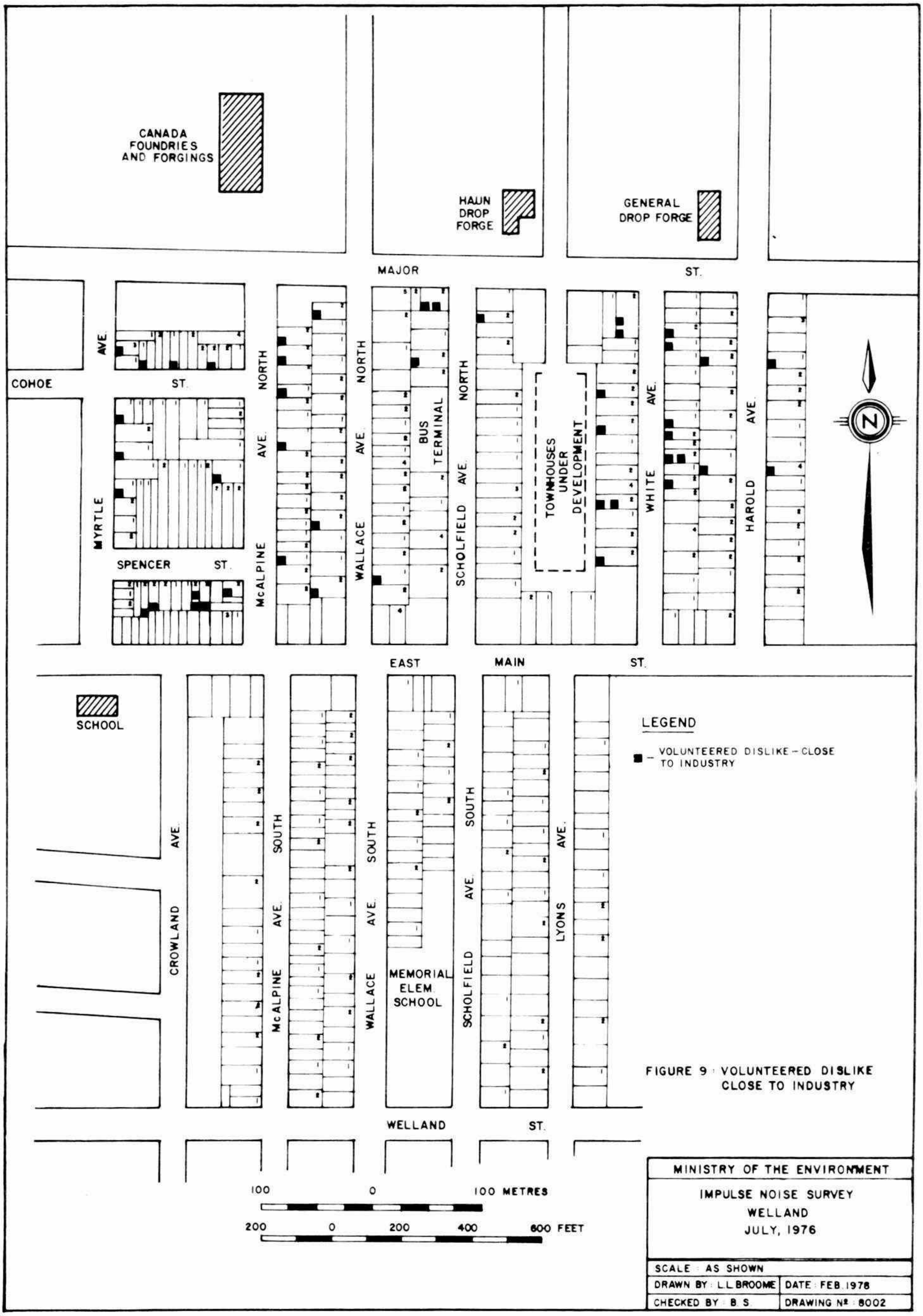



FIGURE 9: VOLUNTEERED DISLIKE CLOSE TO INDUSTRY

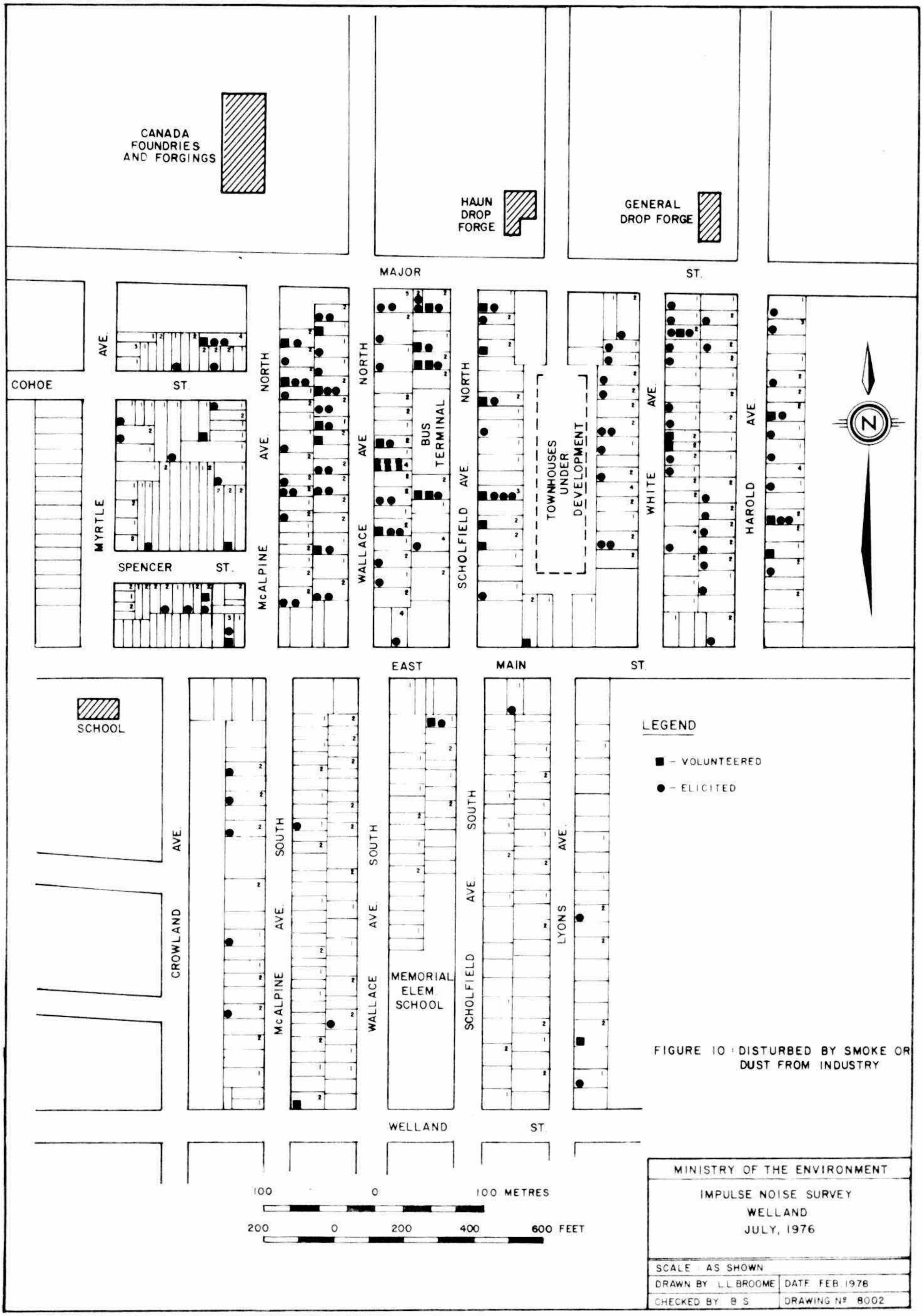
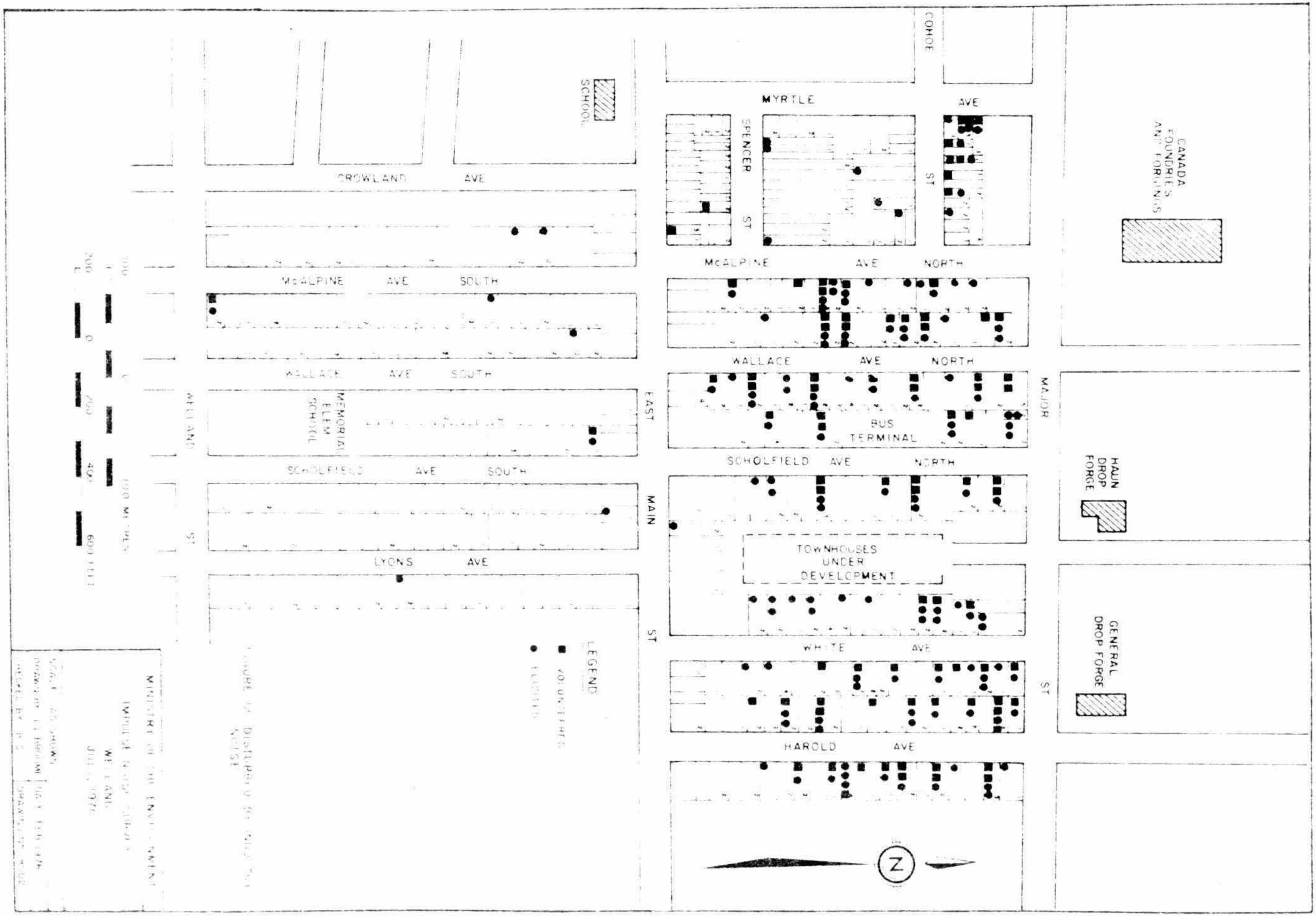



FIGURE 10 : DISTURBED BY SMOKE OR DUST FROM INDUSTRY


CANADA FOUNDRIES AND FORGINGS
HAUN DROP FORGE
GENERAL DROP FORGE
MAJOR ST.
COHOE ST.
MYRTLE AVE.
SPENCER ST.
McALPINE AVE. NORTH
WALLACE AVE. NORTH
BUS TERMINAL
SCHOLFIELD AVE. NORTH
TOWNHOUSES UNDER DEVELOPMENT
WHITE AVE.
HAROLD AVE.
N
EAST MAIN ST.
SCHOOL
CROWLAND AVE.
McALPINE AVE. SOUTH
WALLACE AVE. SOUTH
MEMORIAL ELEM. SCHOOL
SCHOLFIELD AVE. SOUTH
LYONS AVE.
LEGEND
■ - VOLUNTEERED
● - ELICITED
FIGURE 11 : DISLIKE NOISE (ANY) IN NEIGHBOURHOOD
WELLAND ST.
100 0 100 METRES
200 0 200 400 600 FEET
MINISTRY OF THE ENVIRONMENT
IMPULSE NOISE SURVEY
WELLAND
JULY, 1976
SCALE AS SHOWN
DRAWN BY L.L.BROOME
DATE FEB 1976
CHECKED BY B.S.
DRAWING Nº 8002


CROWLAND AVE
McALPINE AVE SOUTH
WALLACE AVE SOUTH
SCHOLFIELD AVE SOUTH
LYONS AVE
MYRTLE AVE
McALPINE AVE NORTH
WALLACE AVE NORTH
SCHOLFIELD AVE NORTH
WHITE AVE
HAROLD AVE
SPENCER ST
COHOE ST
EAST MAIN ST
MAJOR ST
WELLAND ST
SCHOOL
MEMORIAL ELEM SCHOOL
BUS TERMINAL
TOWNHOUSES UNDER DEVELOPMENT
CANADA FOUNDRIES AND FORGINGS
HAUN DROP FORGE
GENERAL DROP FORGE
LEGEND
N

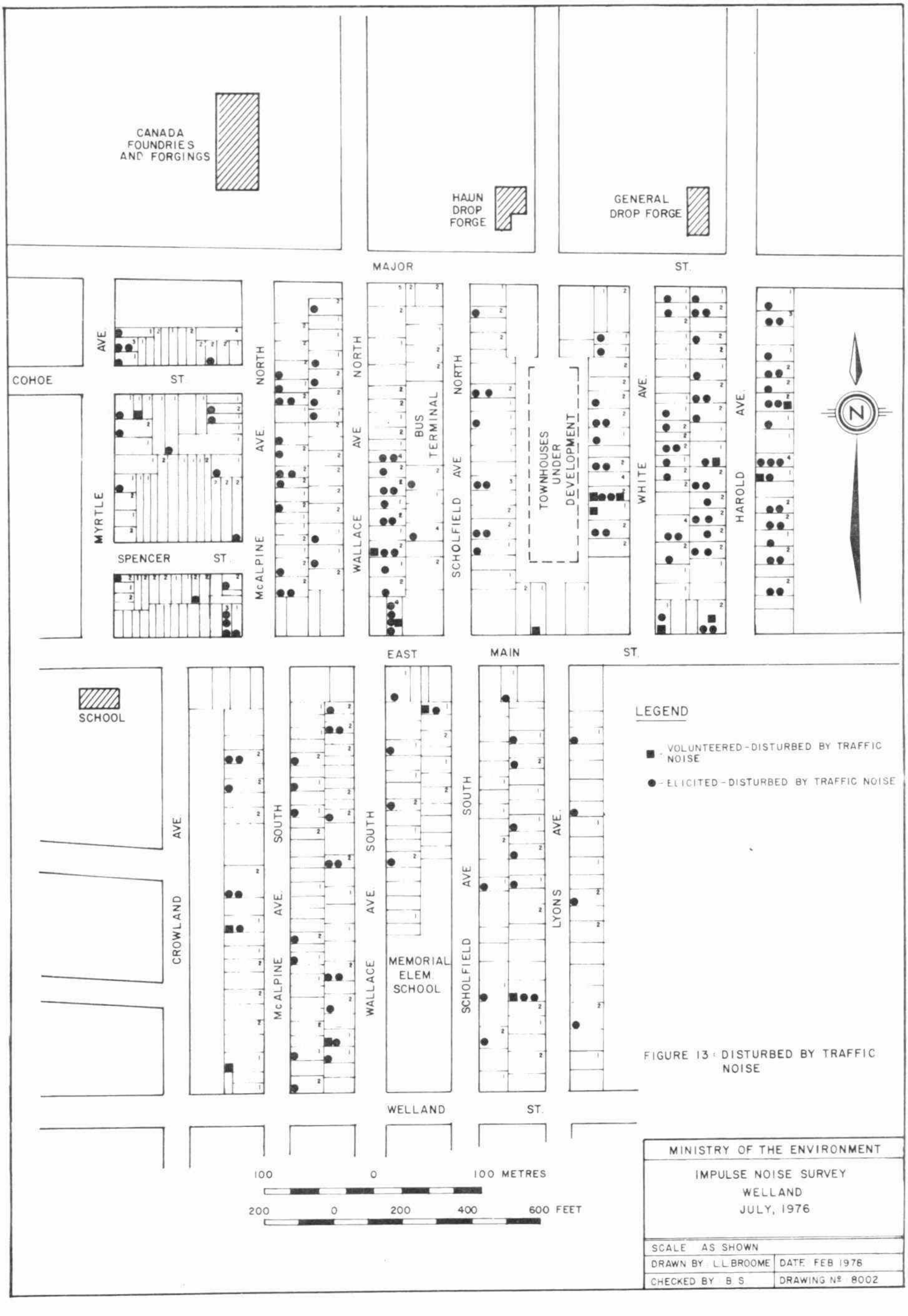


FIGURE 13: DISTURBED BY TRAFFIC NOISE

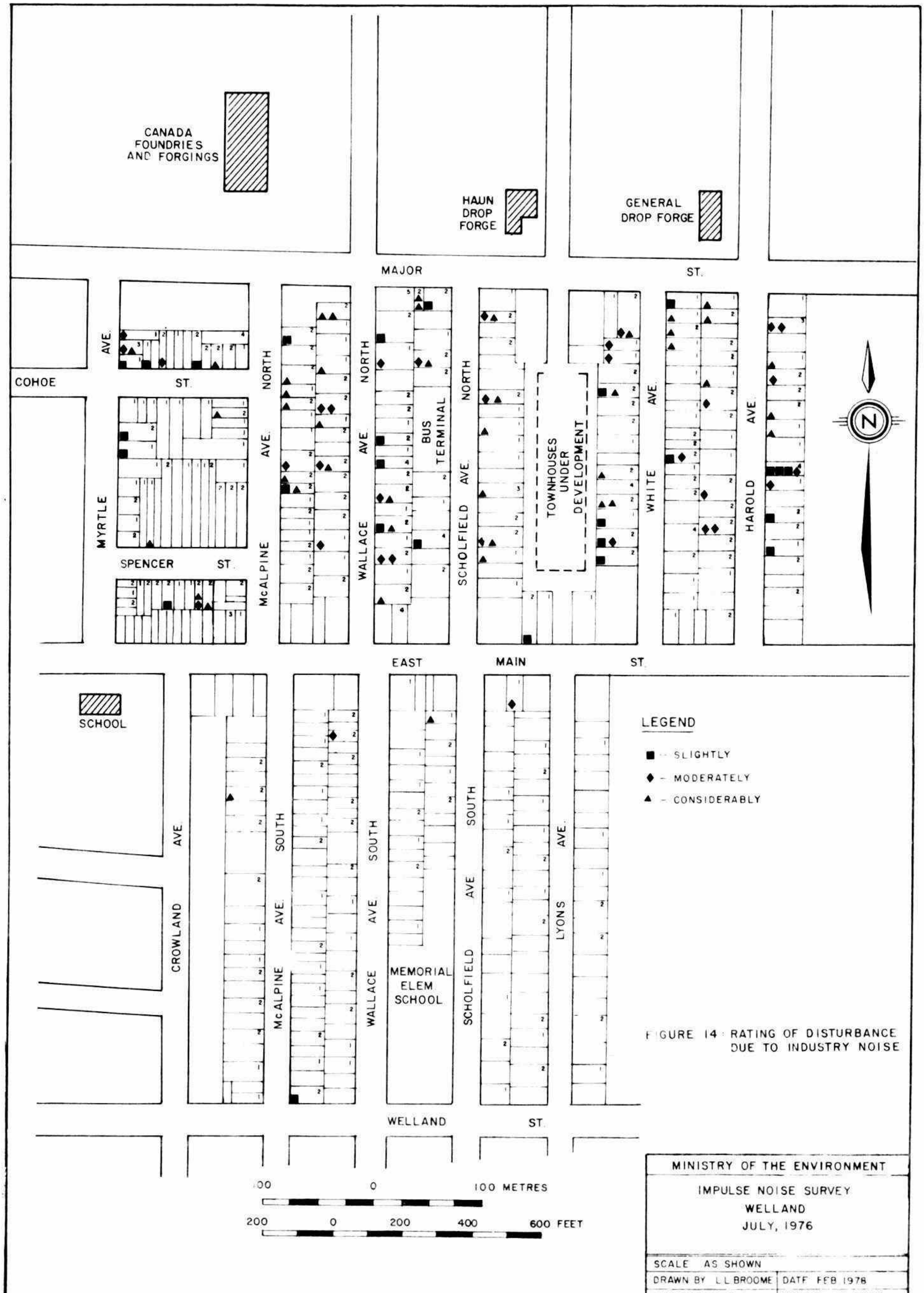


FIGURE 14: RATING OF DISTURBANCE DUE TO INDUSTRY NOISE

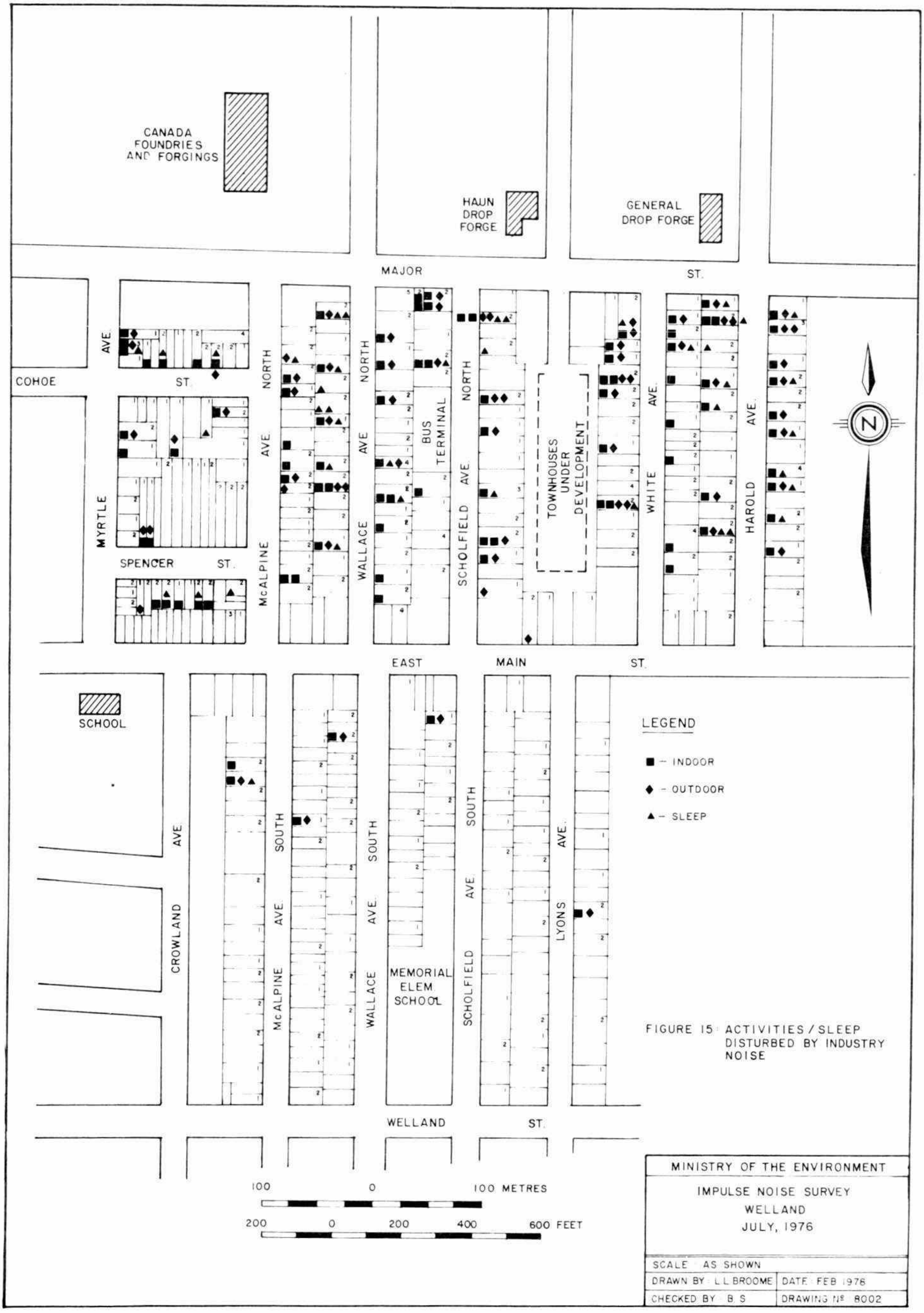



FIGURE 15: ACTIVITIES / SLEEP DISTURBED BY INDUSTRY NOISE

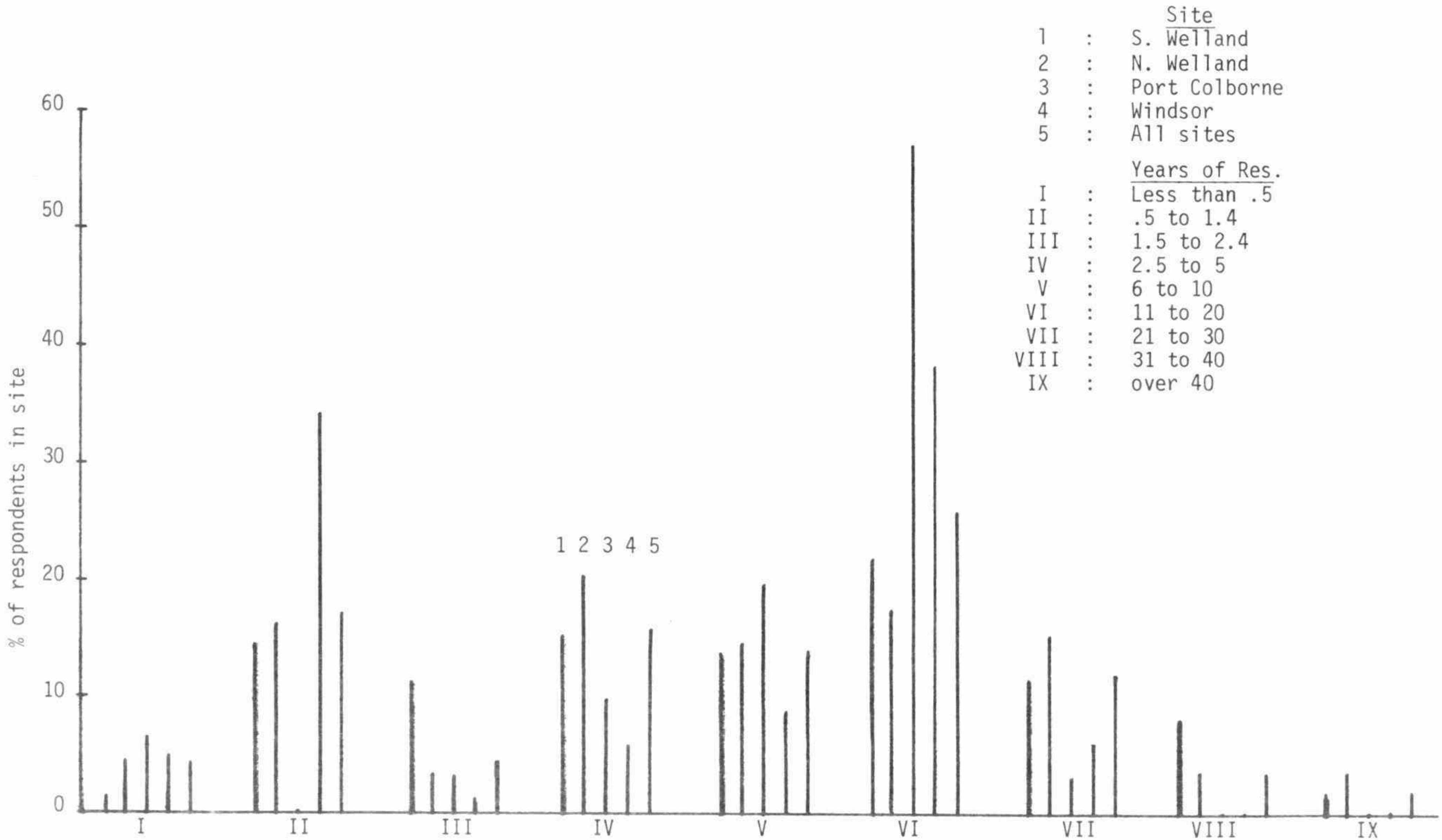



Fig. 16: Distribution of years of residence

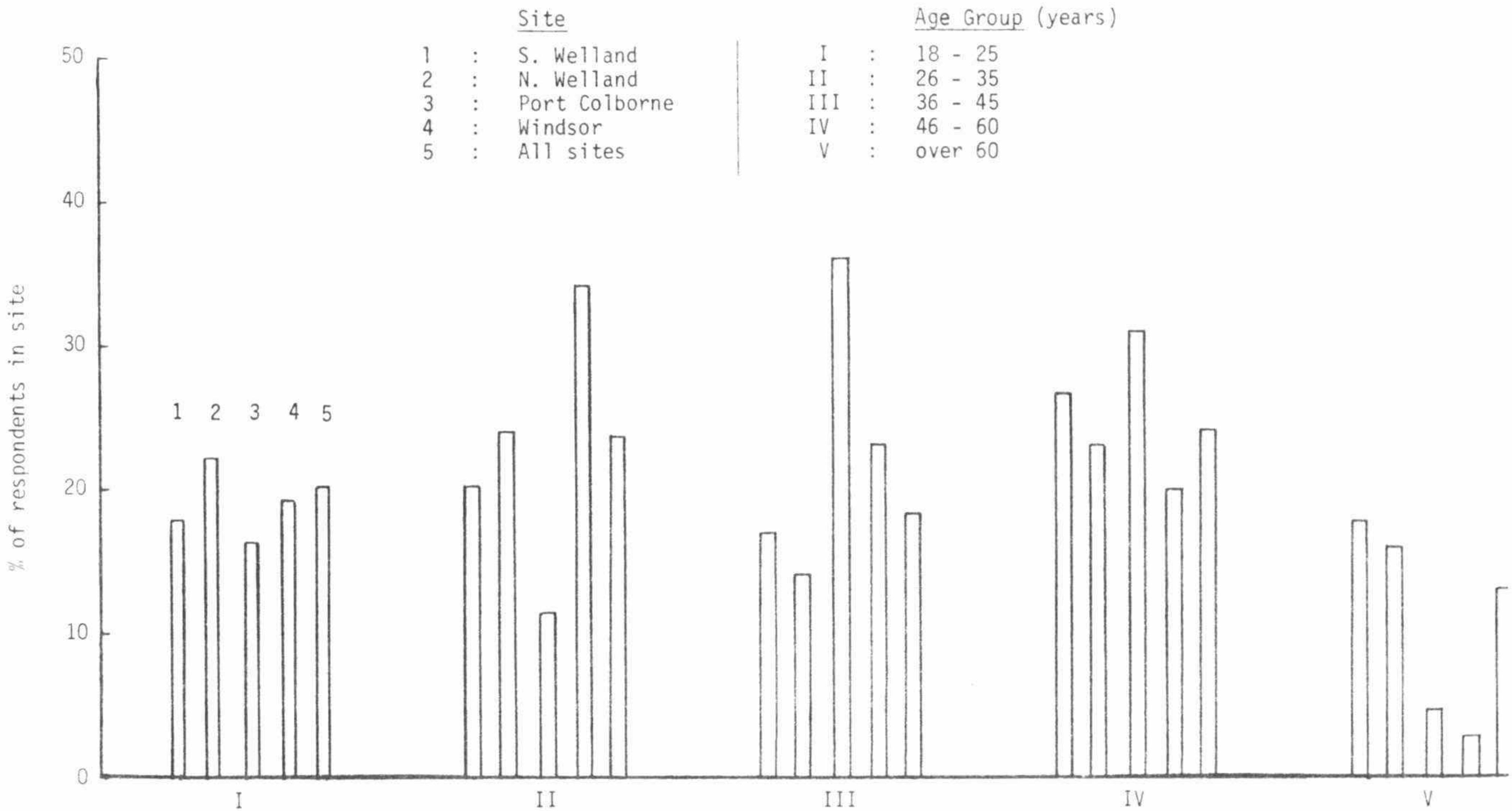



Fig. 17: Distribution of age of respondents

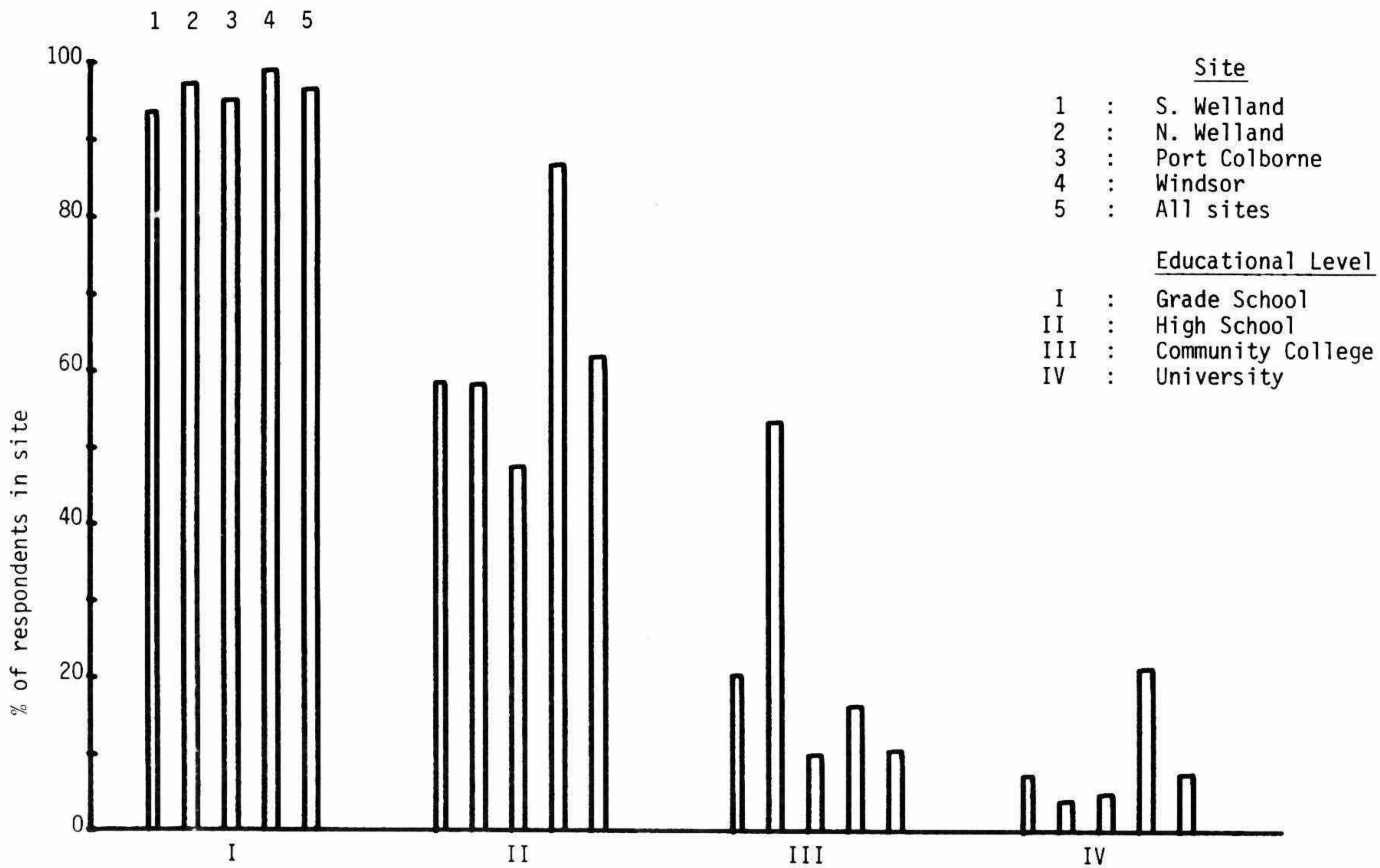



Fig. 18: Distribution of educational level of respondents

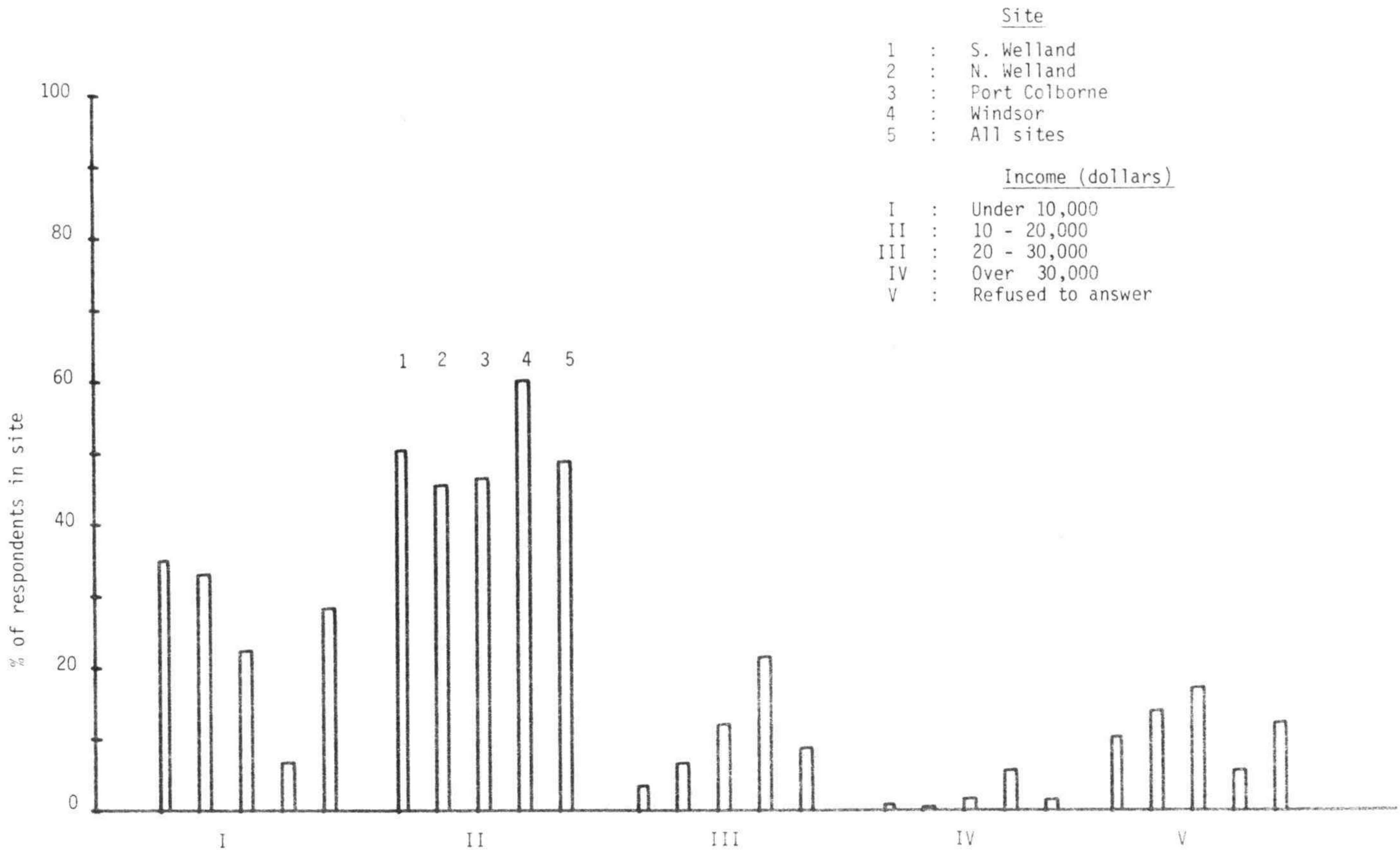



Fig. 19: Distribution of total household income

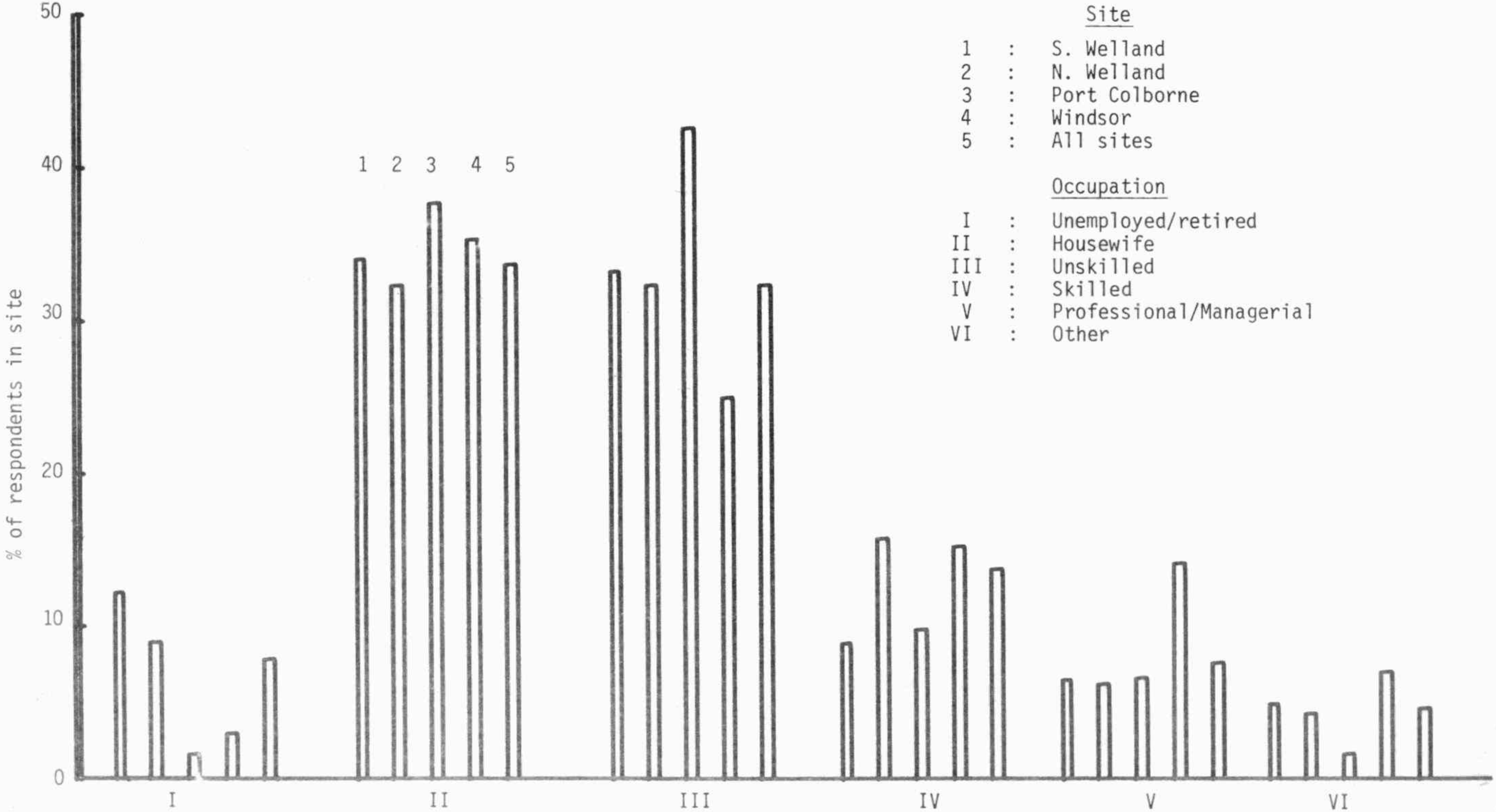



Fig. 20: Distribution of types of occupation

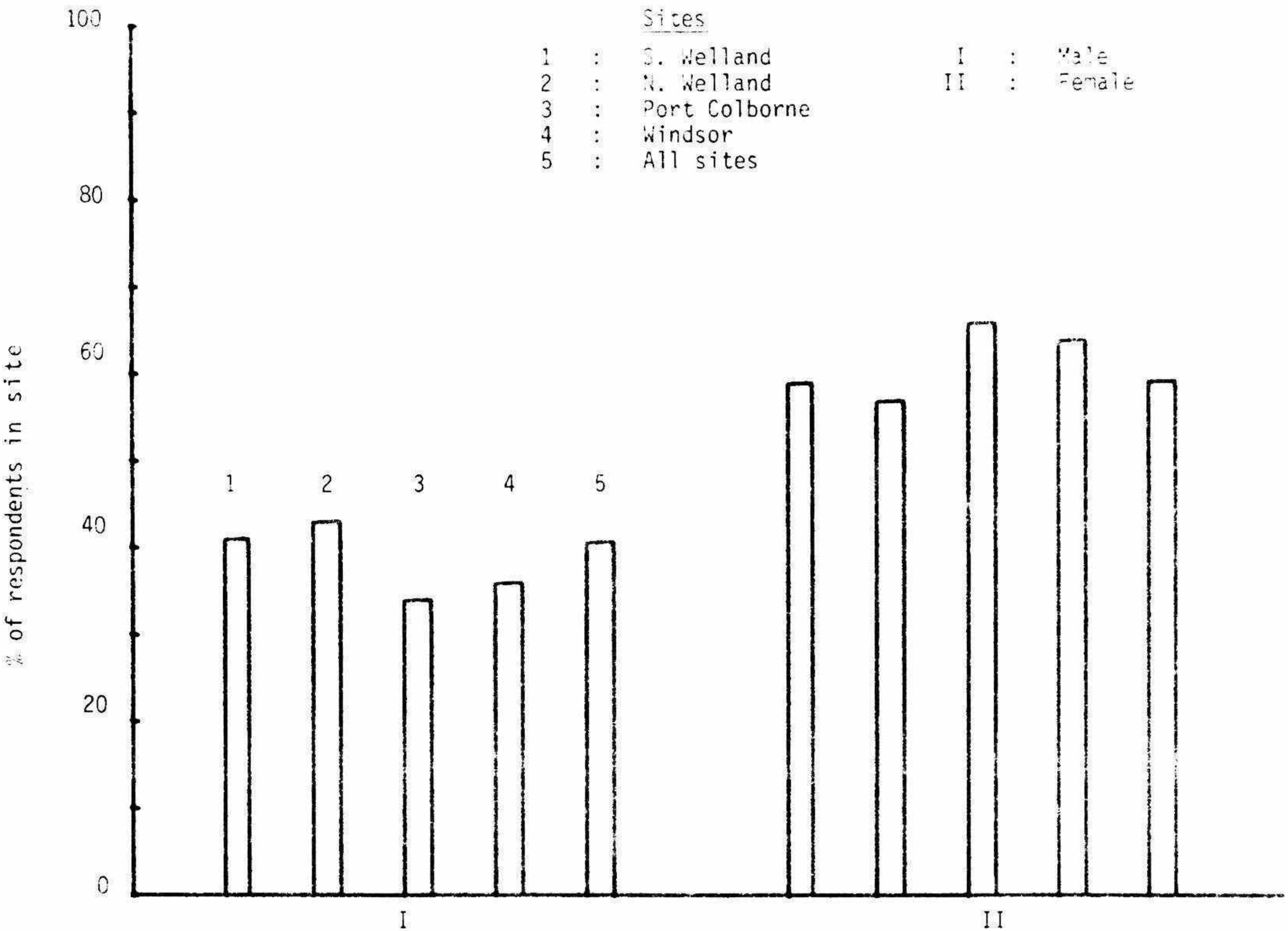



Fig. 21: Distribution of Males and Females

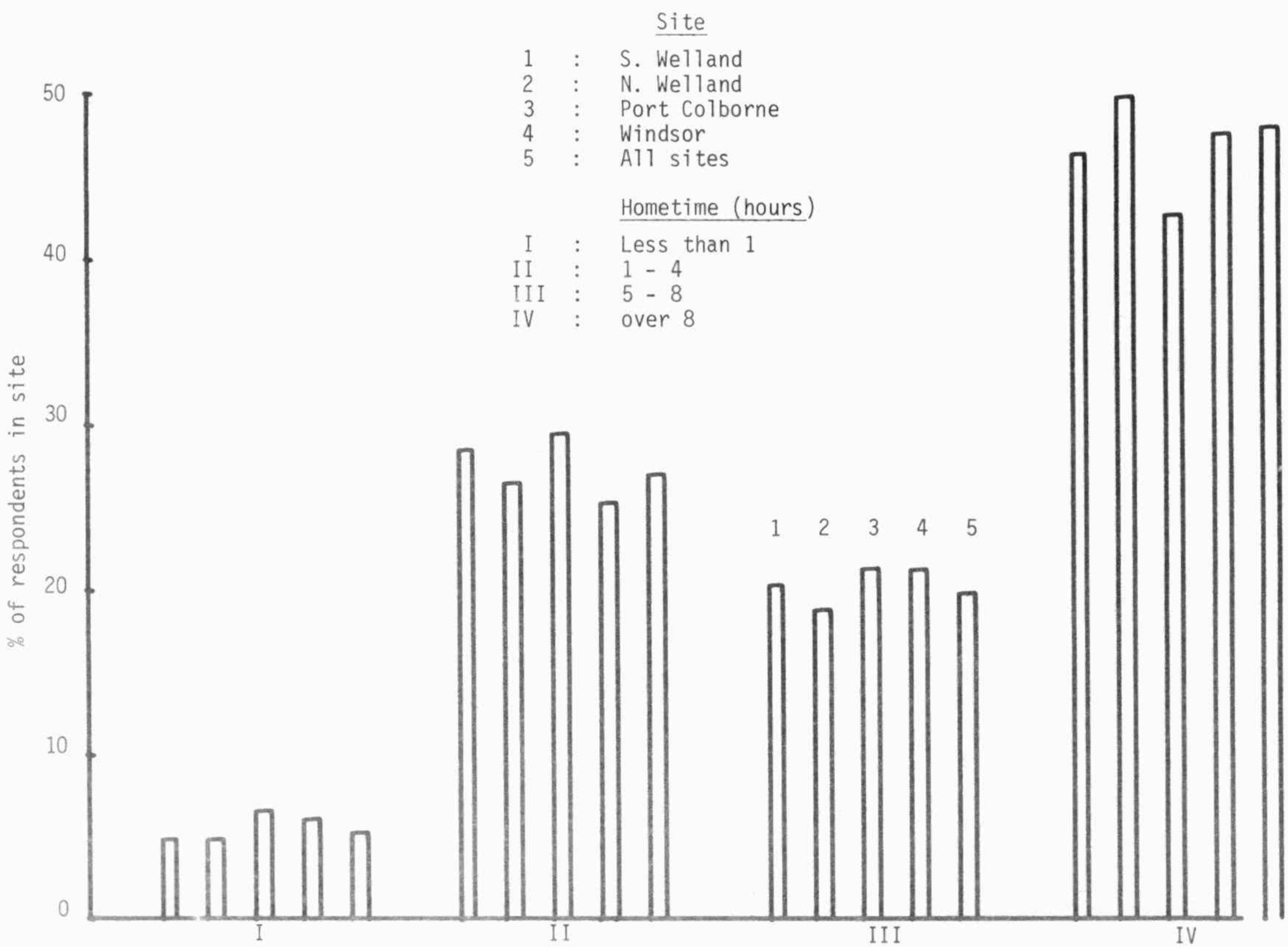



Fig. 22: Distribution of amount of time spent at home on weekdays (Hometime)

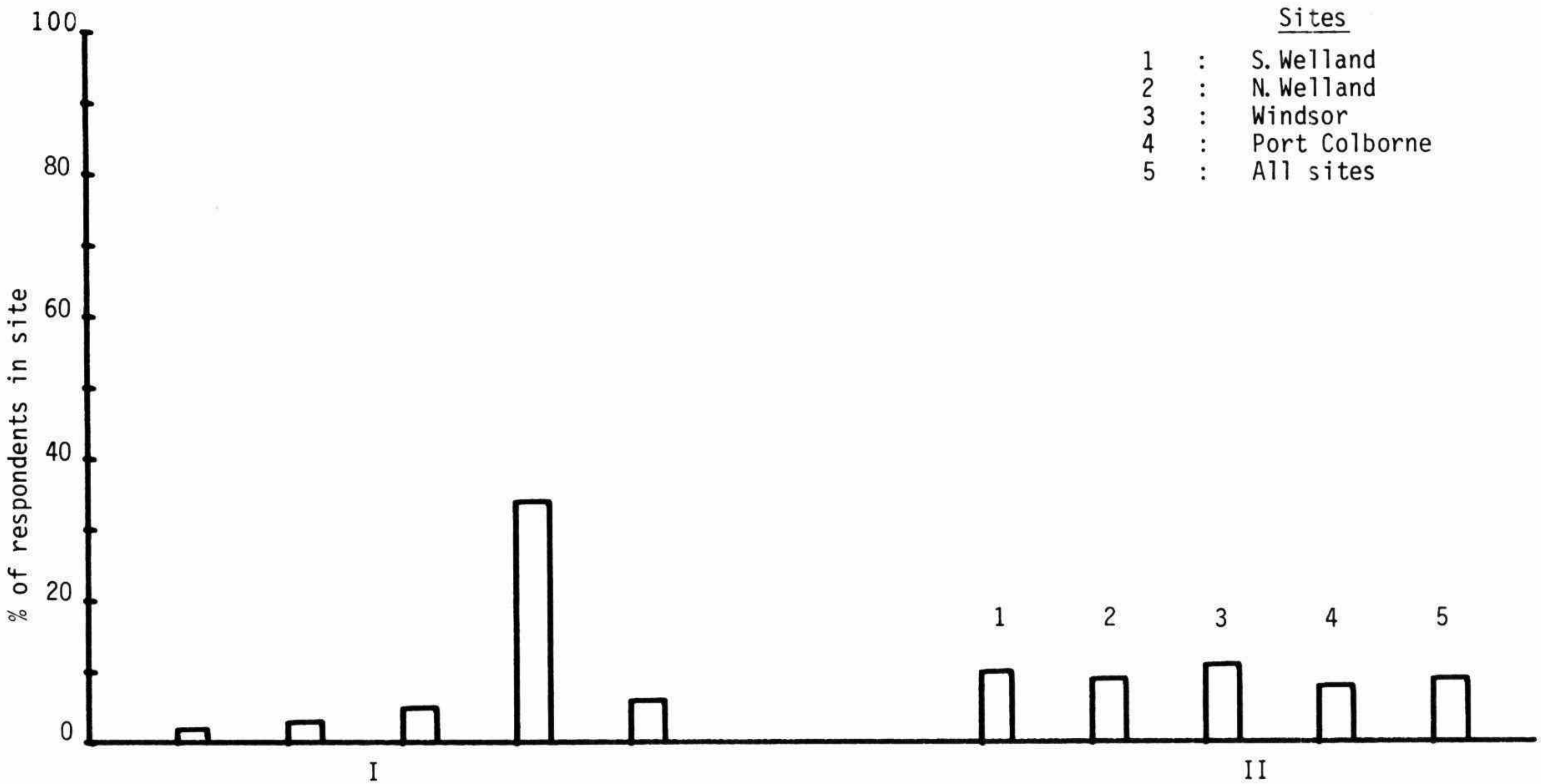
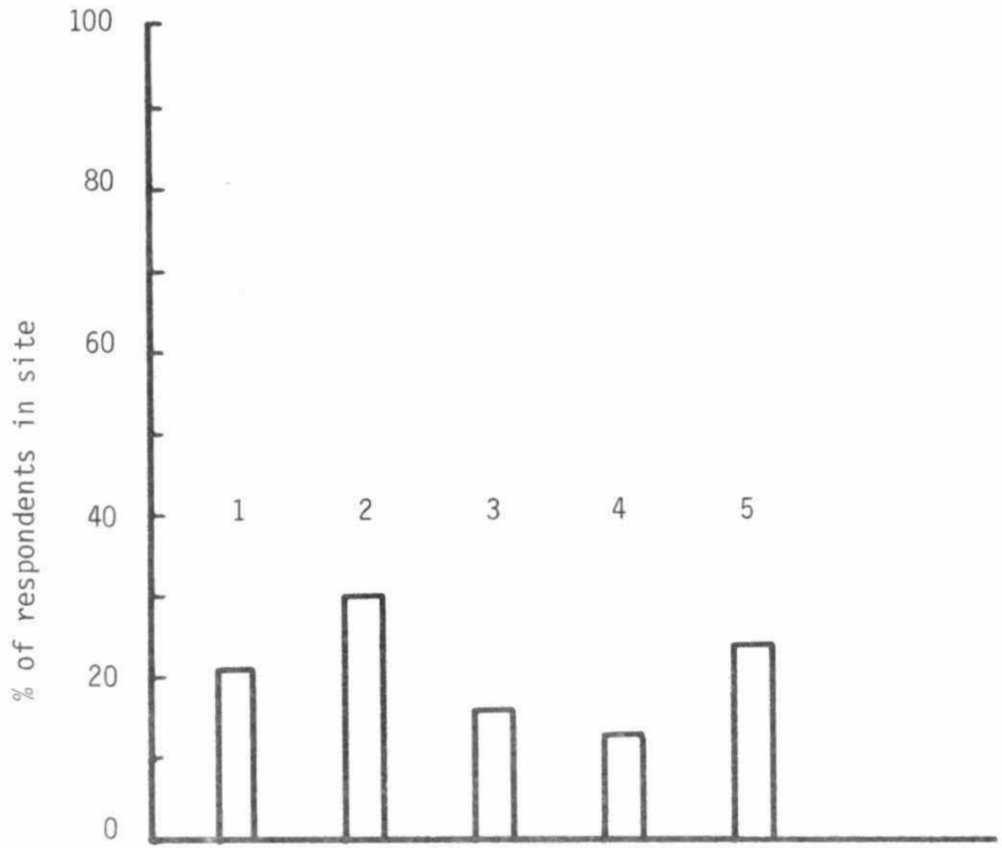



Fig. 23: Percent of respondents in each site who do not "like" location of
I : Shopping facilities
II : Place of work
(Questions 3 and 4)




Site

1 : S. Welland
2 : N. Welland
3 : Windsor
4 : Port Colborne
5 : All sites

Fig. 24: Percent of respondents in each site who expressed that there was "not enough" open space in their neighbourhood. (Question 5)

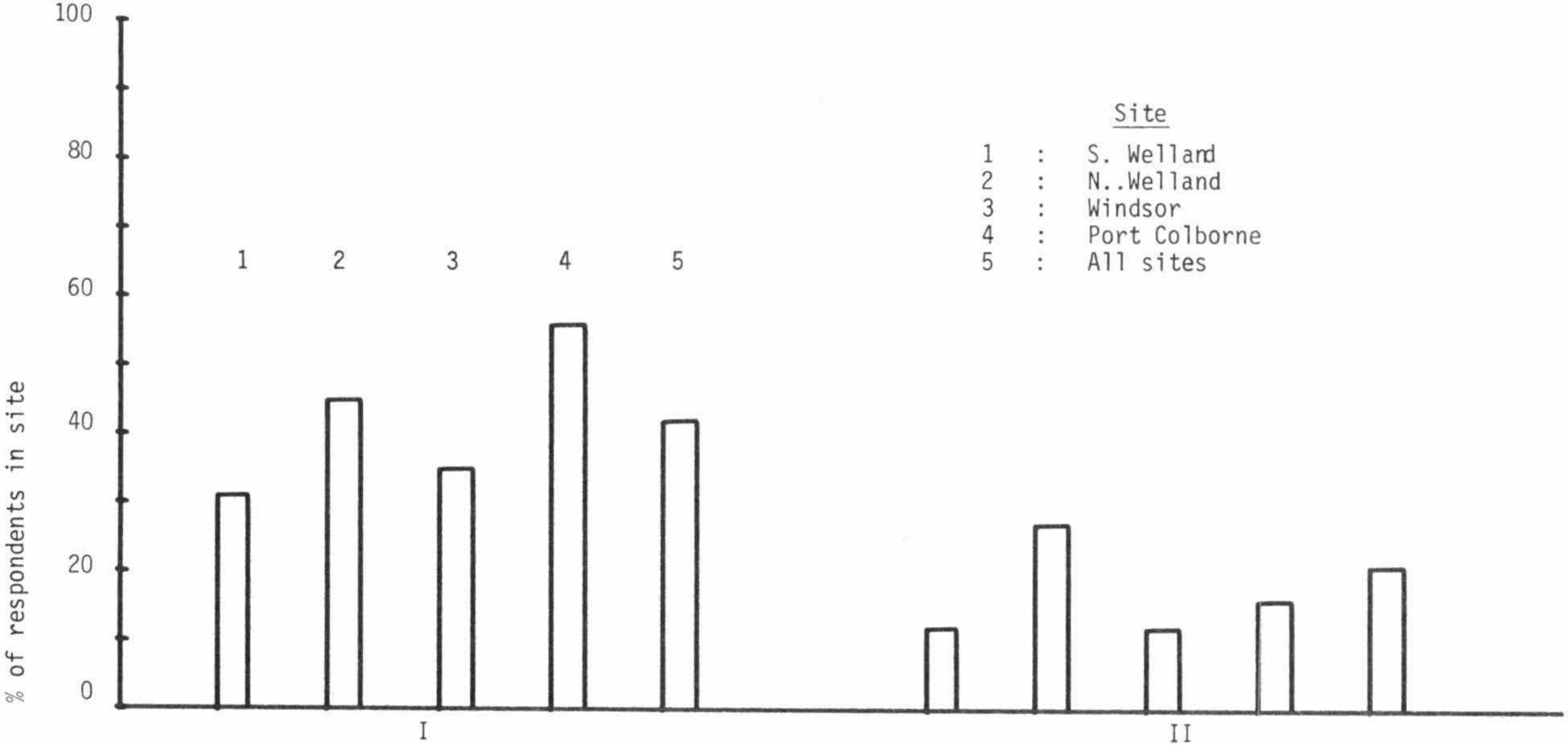



Fig. 25: Percent of respondents in each site who expressed
(I) that there was "not enough" recreational facilities in their neighbourhood
(II) that they would be willing to pay "more " taxes for additional recreational facilities (Question 6)

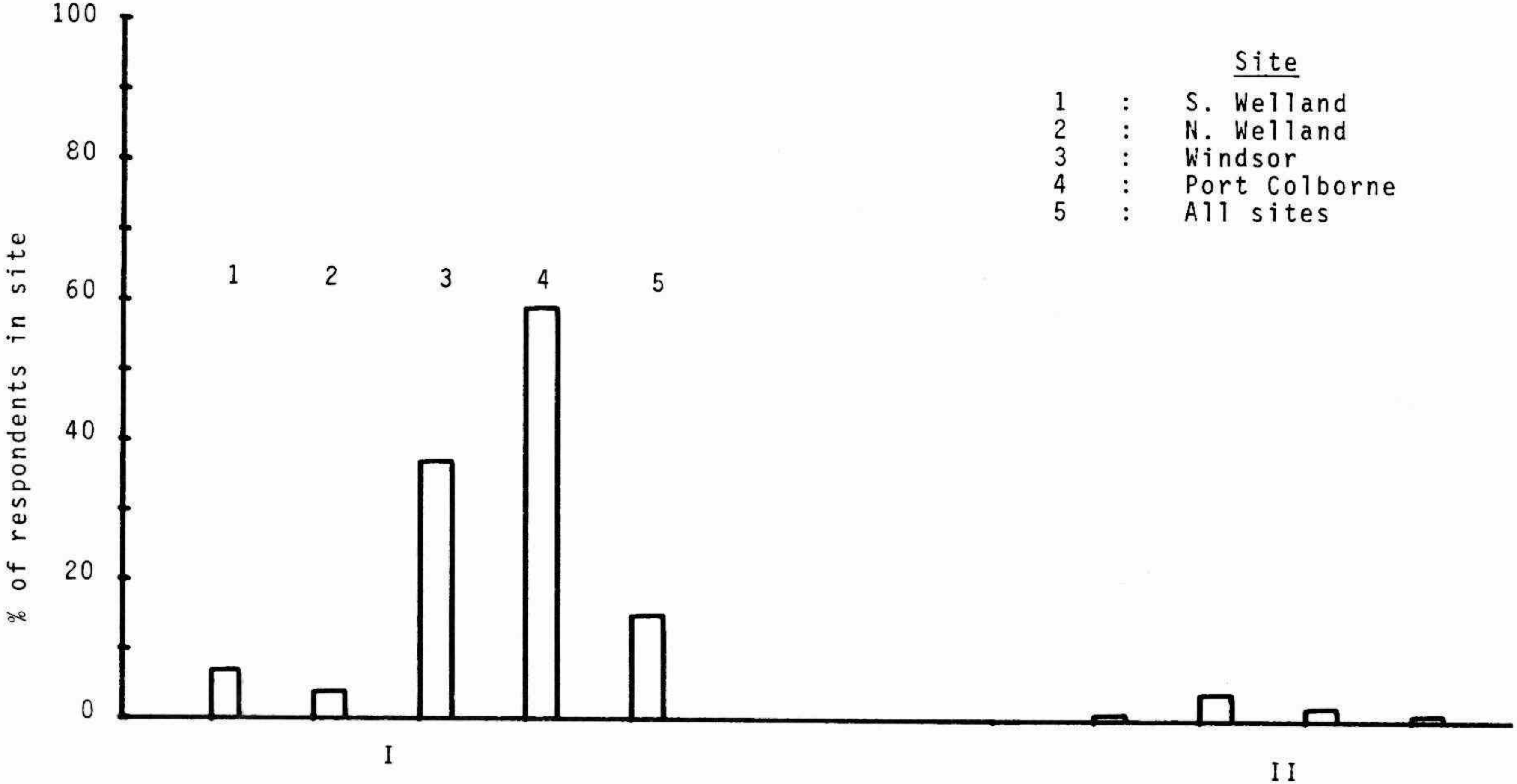



Fig. 26: Percent of respondents who expressed:
(I) that public transporation was "poor" in their area
(II) that their neighbours were "unfriendly"
(Questions 7, 10)

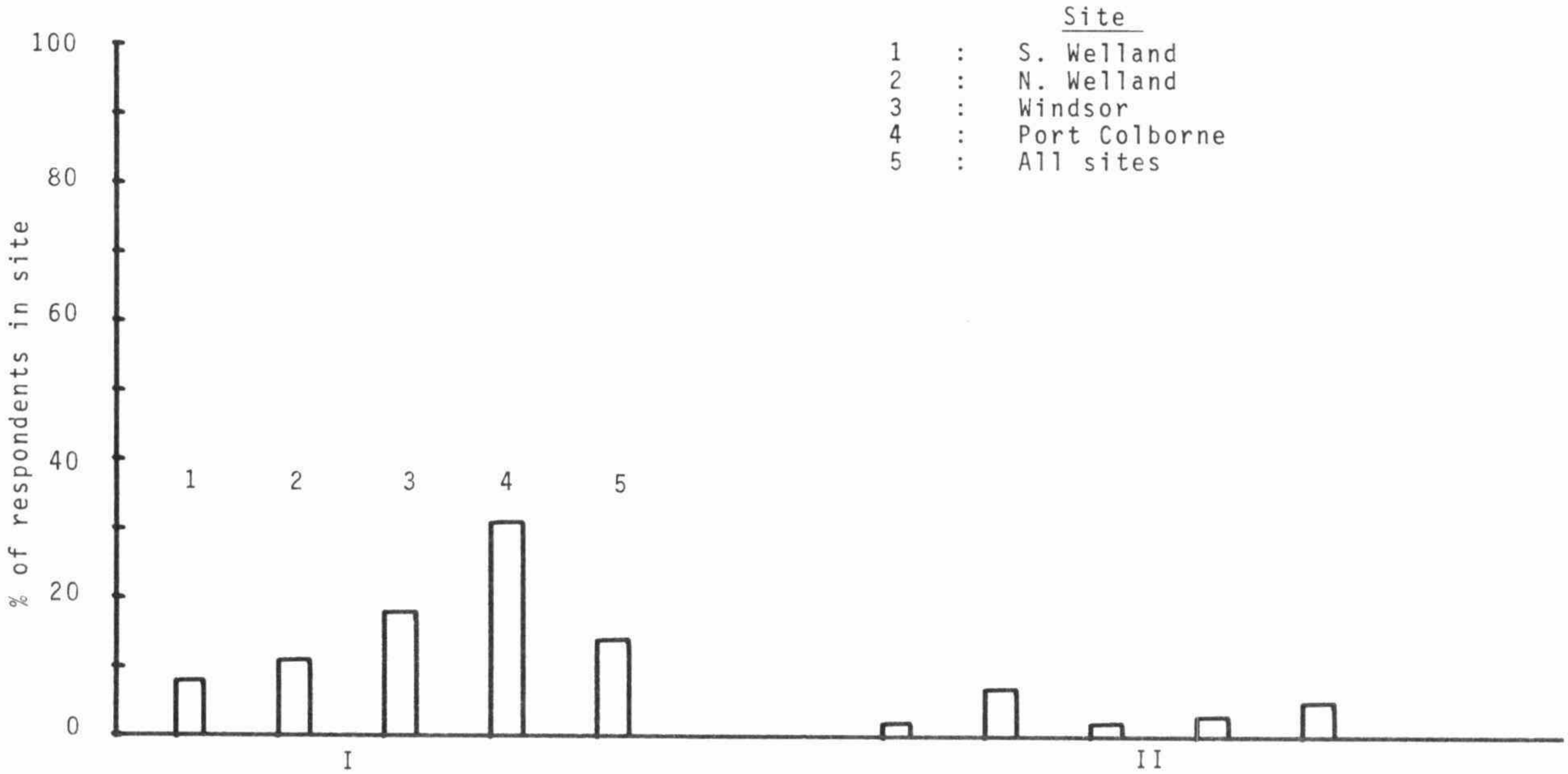



Fig. 27: Percent of respondents who expressed
(I) that city services were "poor" in their neighbourhood
(II) that their neighbourhood was "unsafe"
(Questions 11, 13)

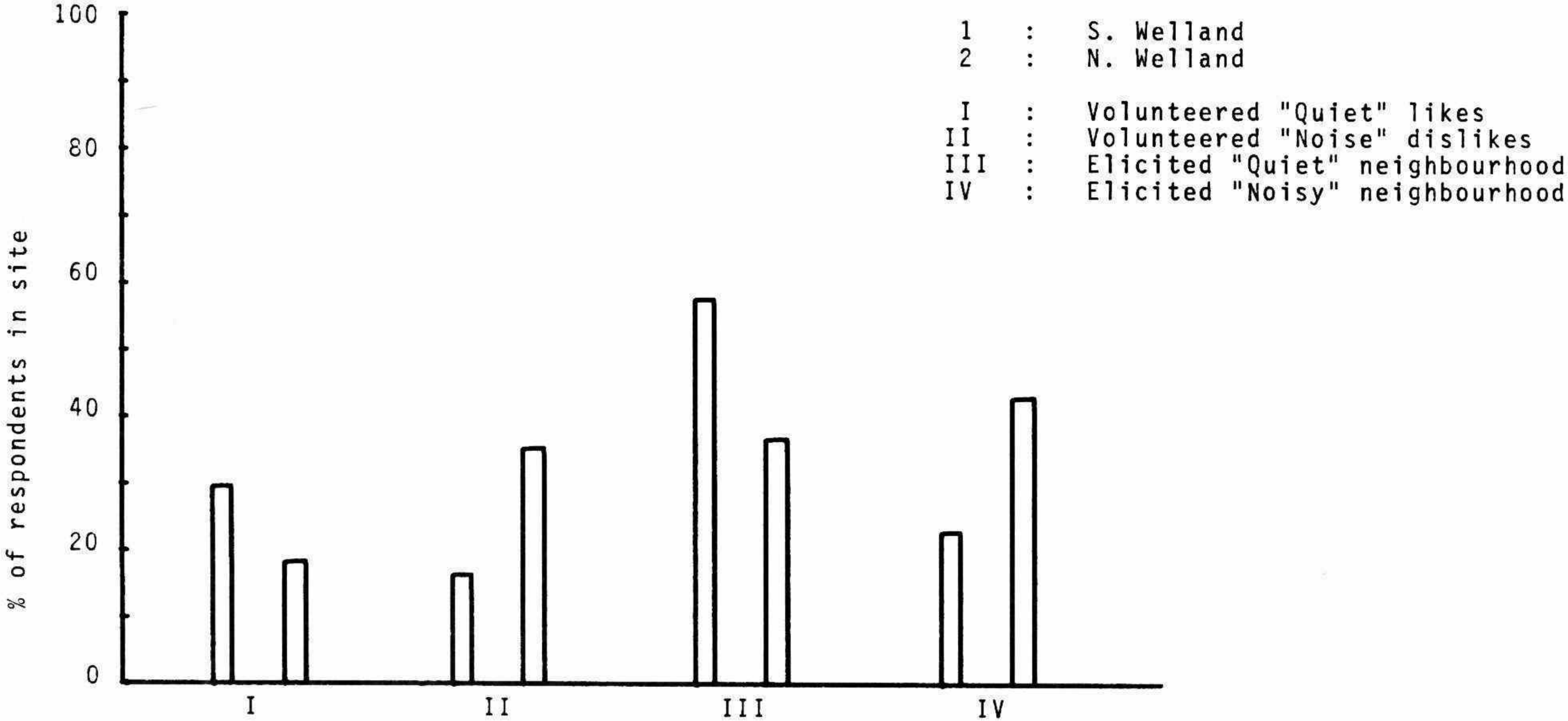



Fig. 28: Neighbourhood quiet/noisy
(Volunteered responses from Q. 2 a, b
Elicited responses from Q. 8)

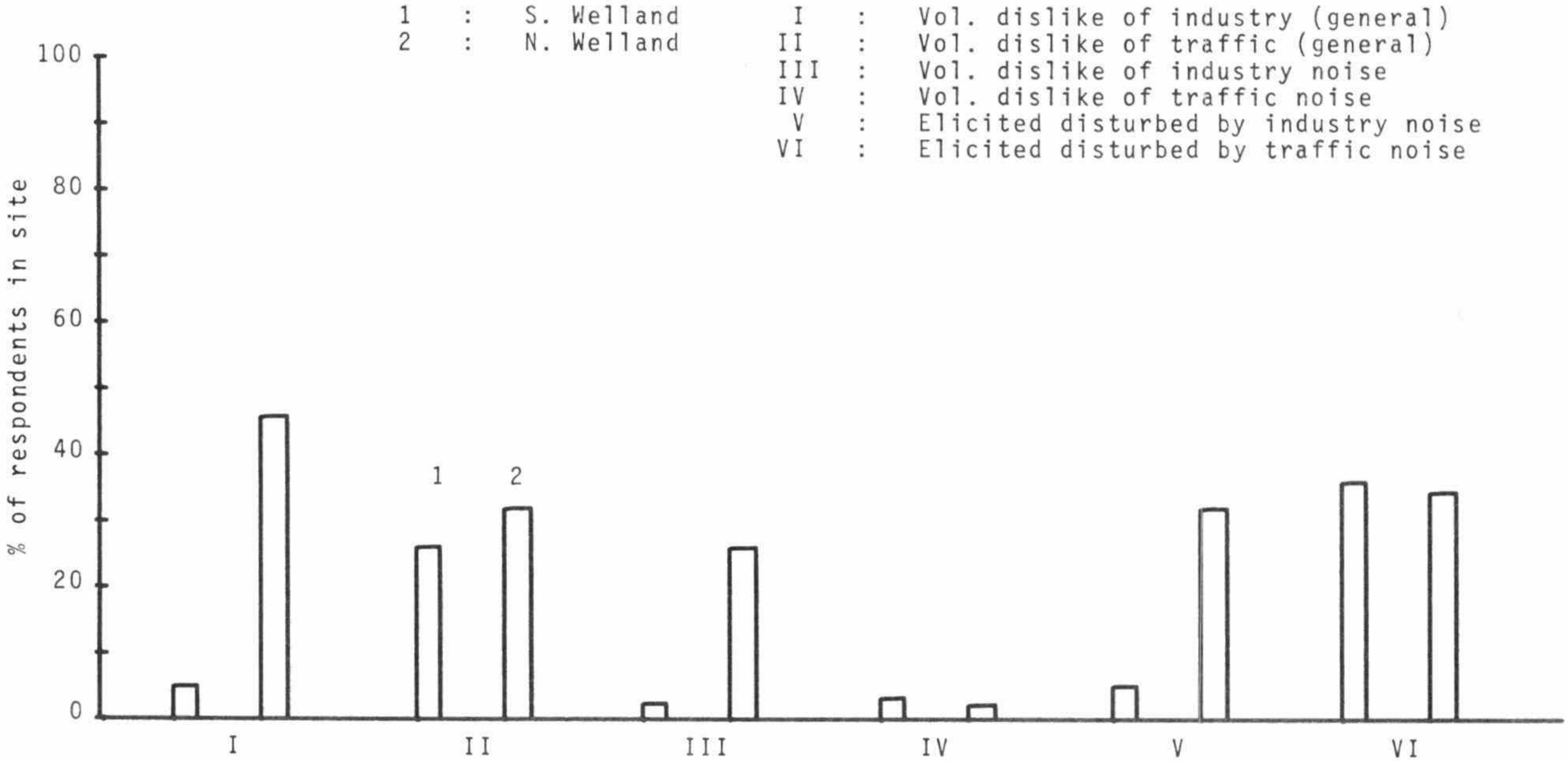



Fig. 29: Reaction to industry and traffic
(Volunteered responses from Q. 2 (b),
Elicited responses from Q. 8)

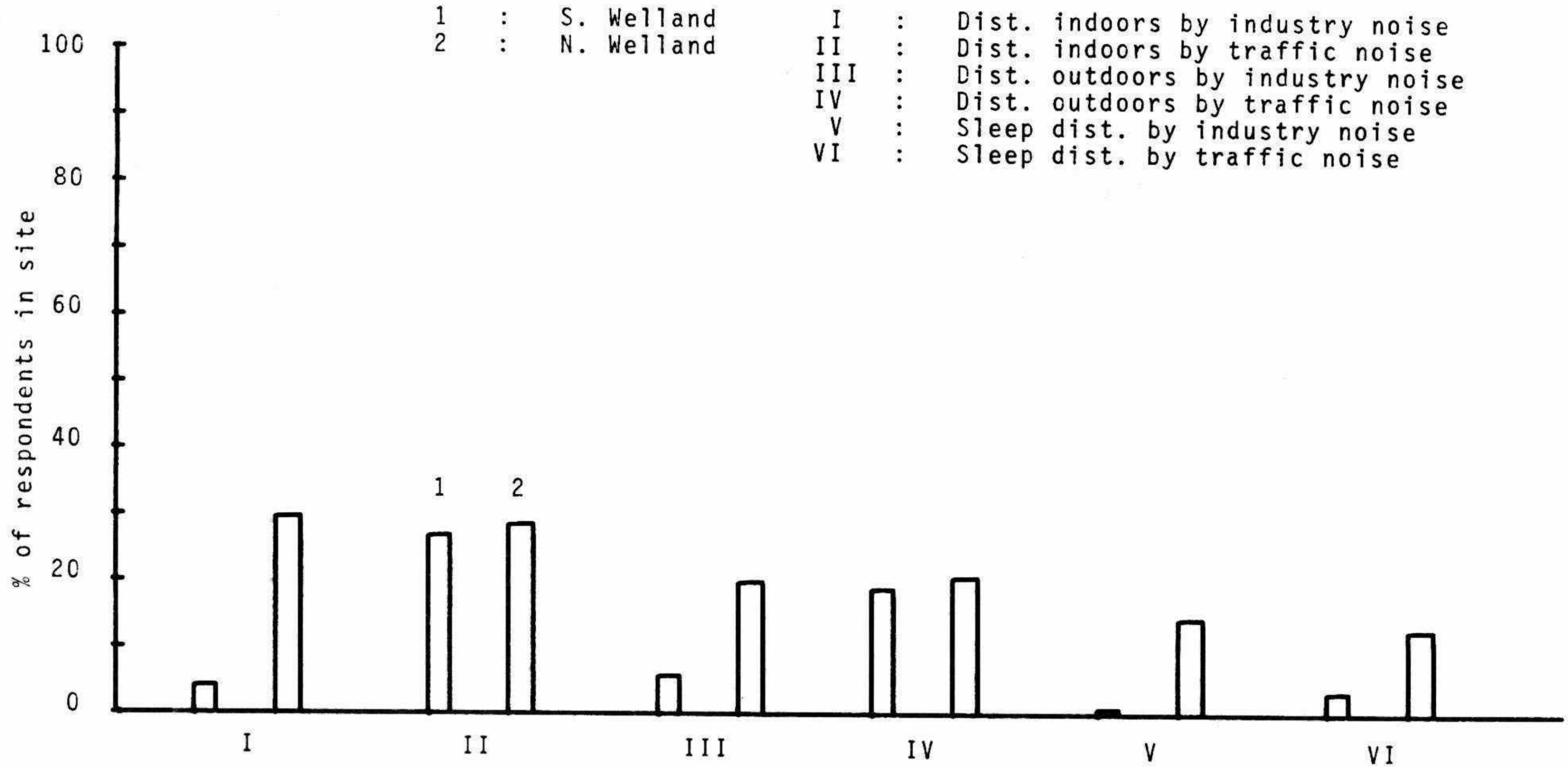



Fig. 30: Activities disturbed by industry/traffic noise (Questions 16, 17, 18)

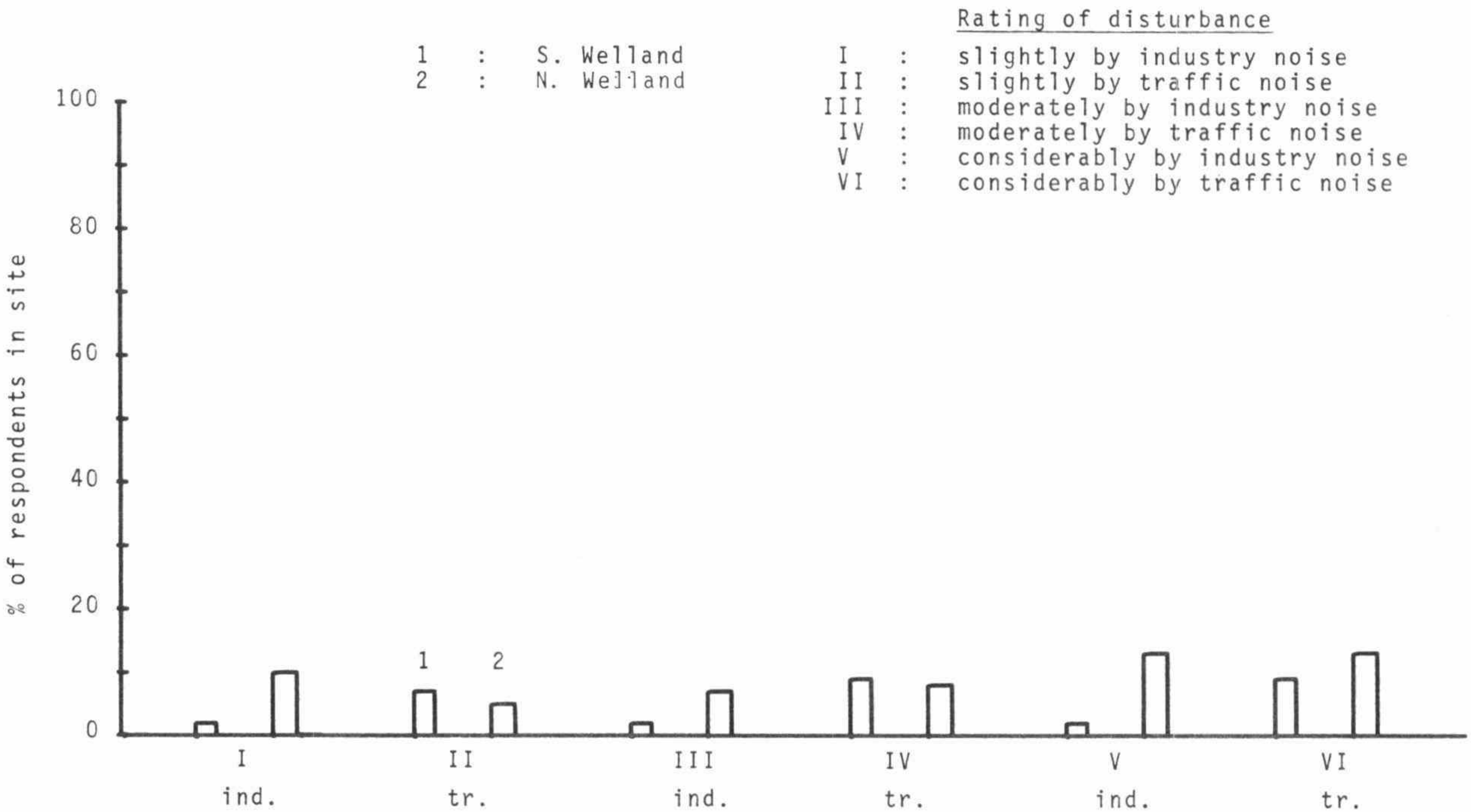



Fig. 31: Rating of disturbance by industry/traffic noise

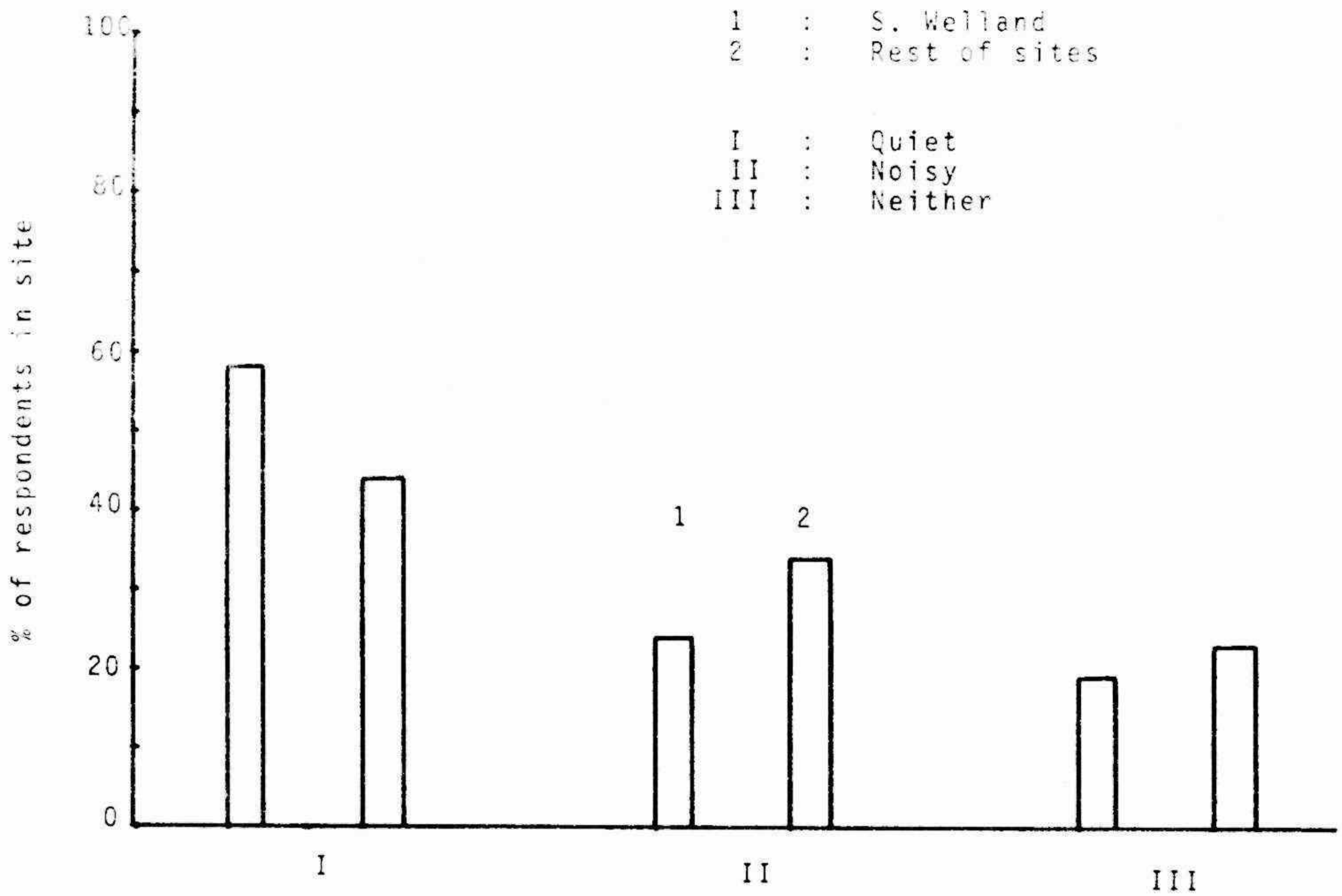



Fig. 32: Neighbourhood quiet/noisy - elicited response (Question 8)

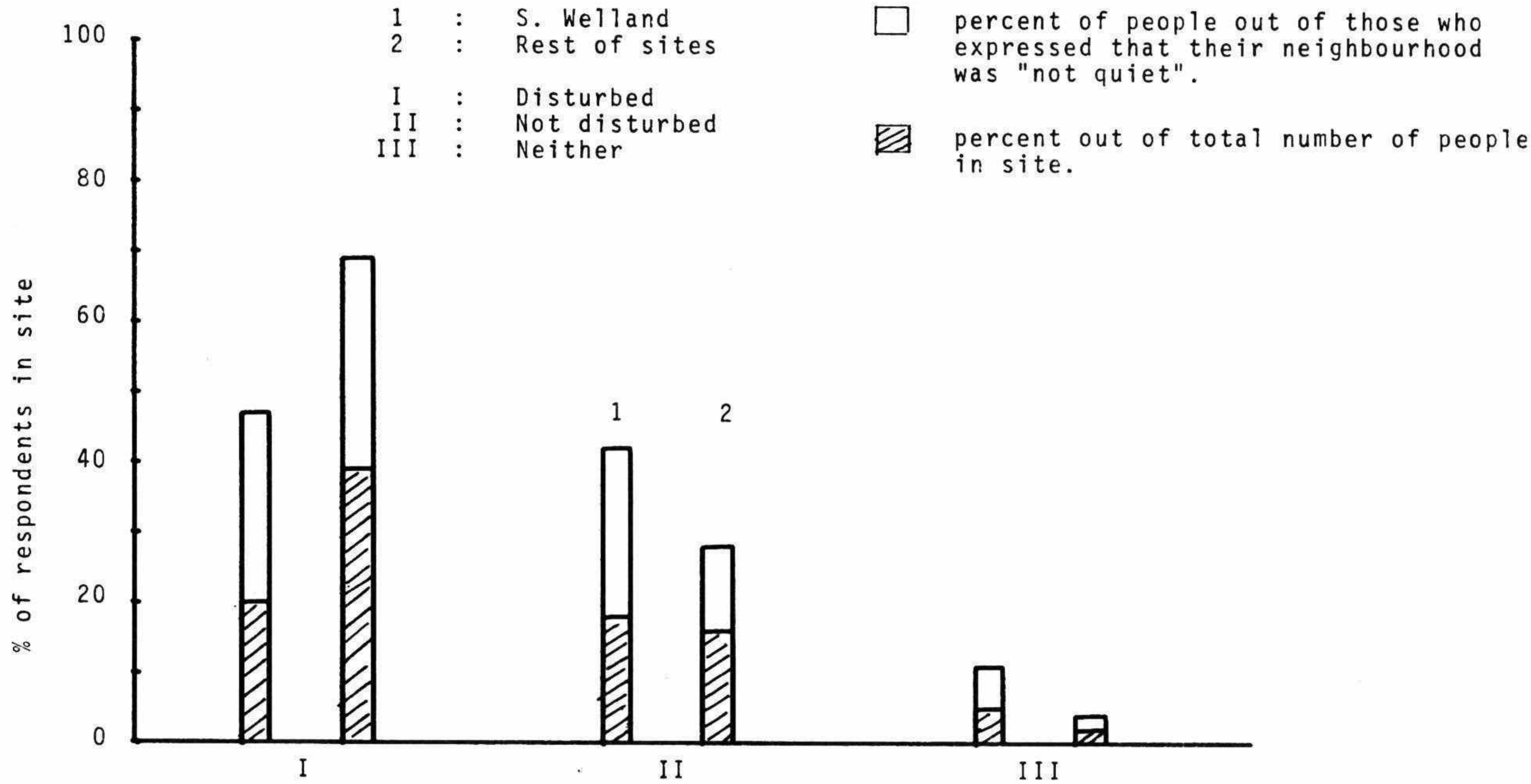



Fig. 33: Disturbed by noise - elicited response
(Question 8)

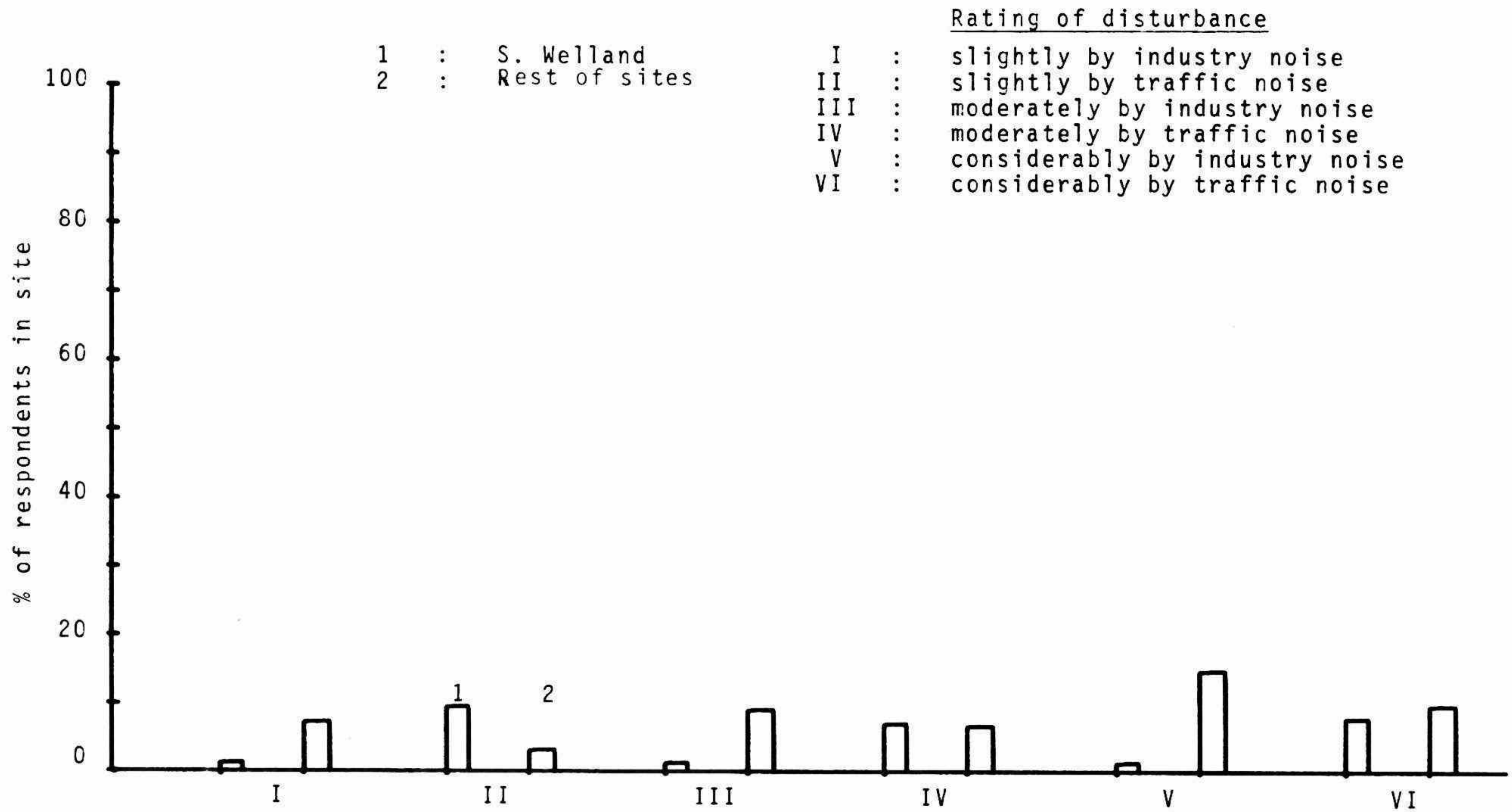



Fig. 34: Rating of disturbance by industry/traffic noise (Question 8)

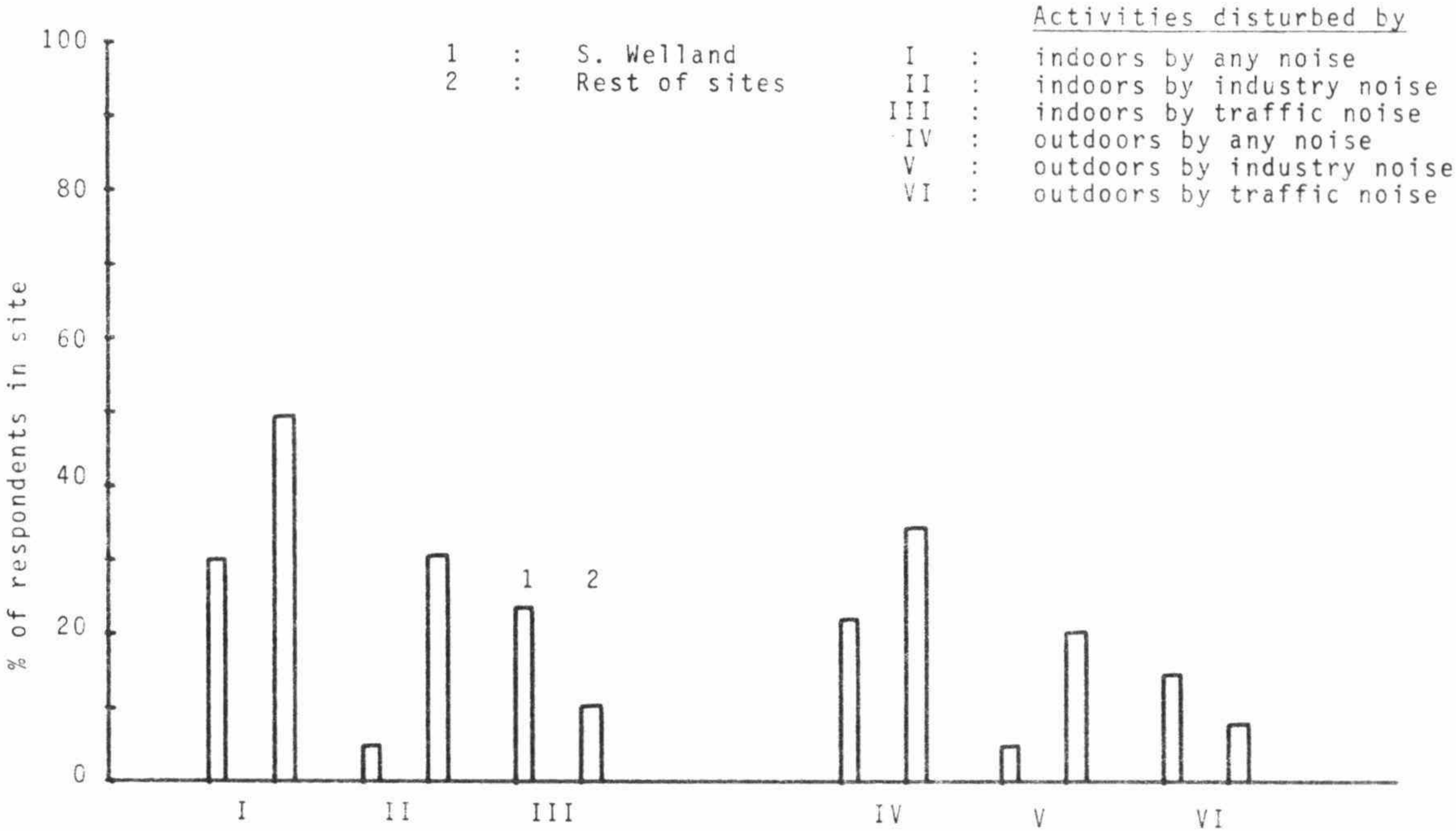



Fig. 35: Activities disturbed by noise
(Question 2, 3, activities)

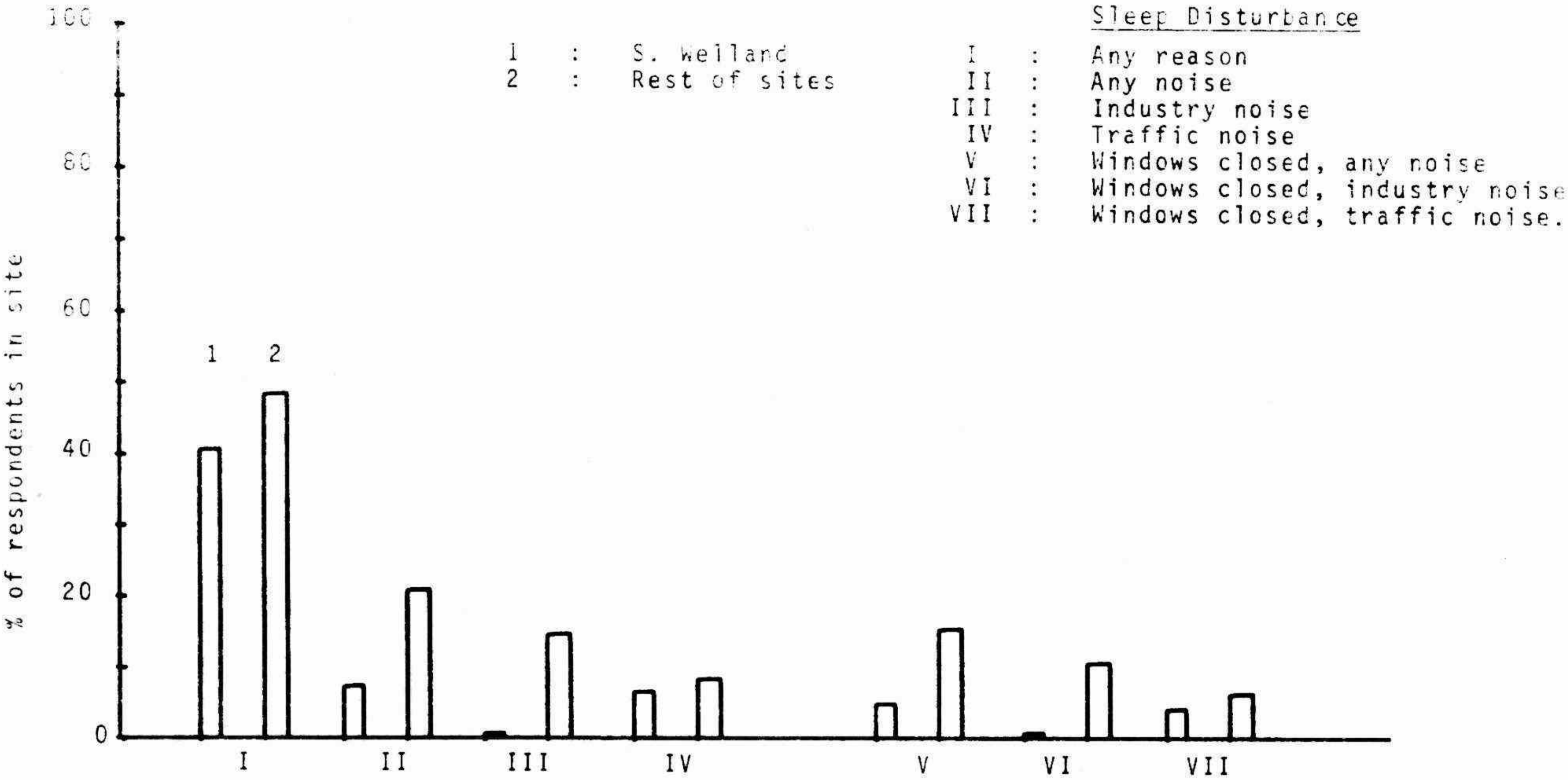



Fig. 36: Sleep disturbance
(Question 18)

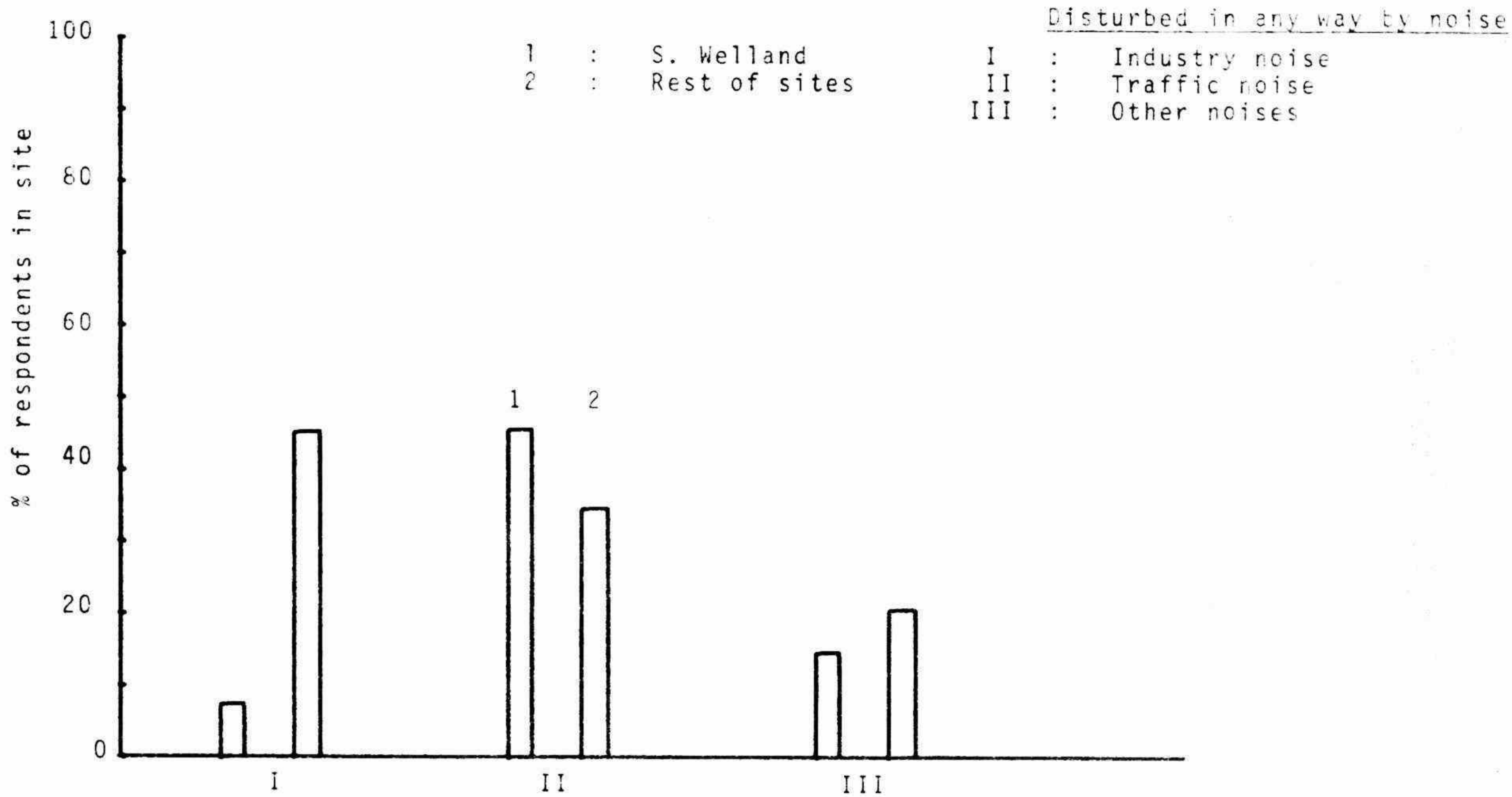



Fig. 37: Disturbed in general by noise from industry/traffic/other (NSANY 1, NSANY 2, NSANY 3)

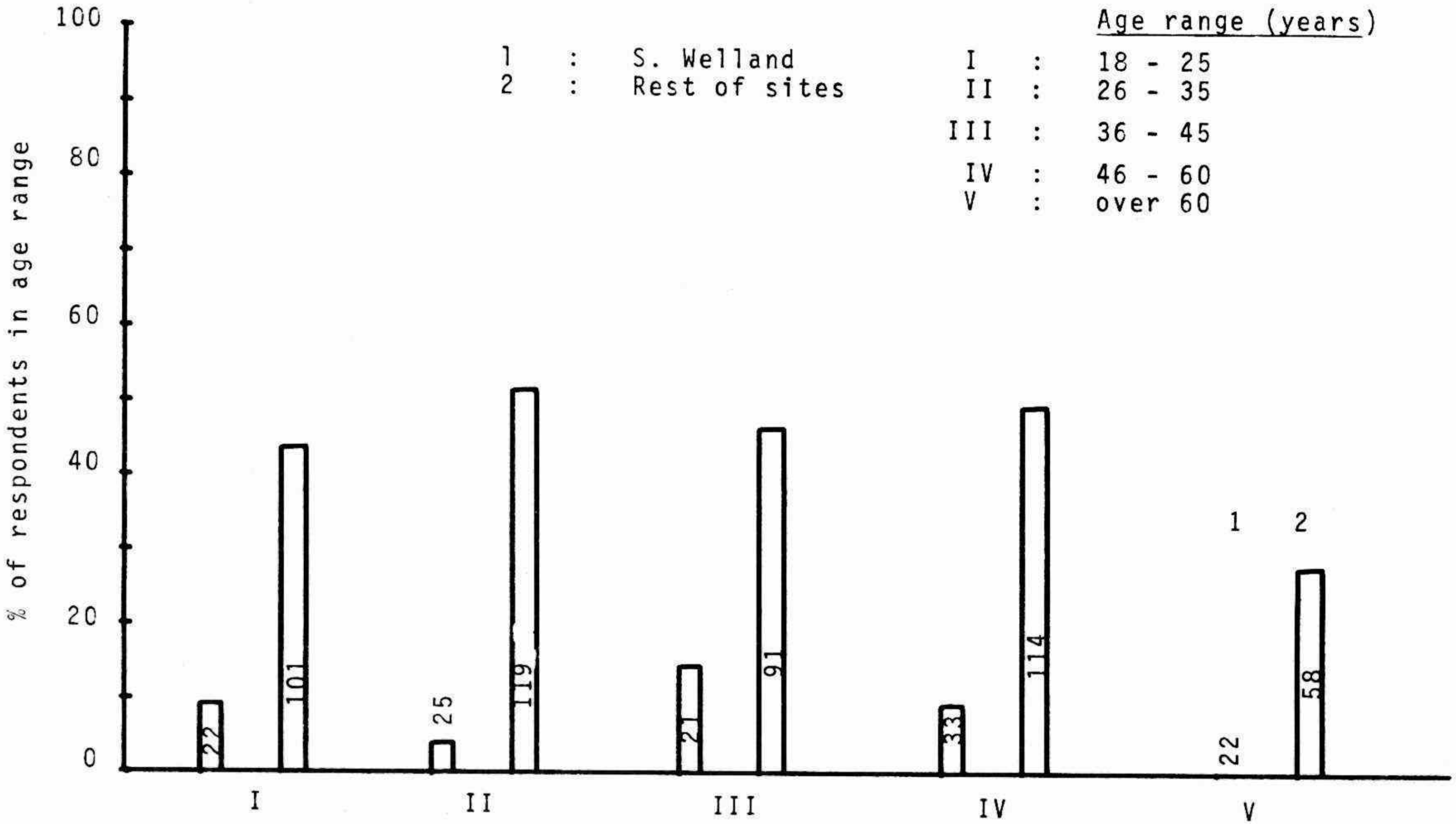



Fig. 38: Disturbed in general by industry noise (NSANY 1)
Cross-tabulated with age of respondents.

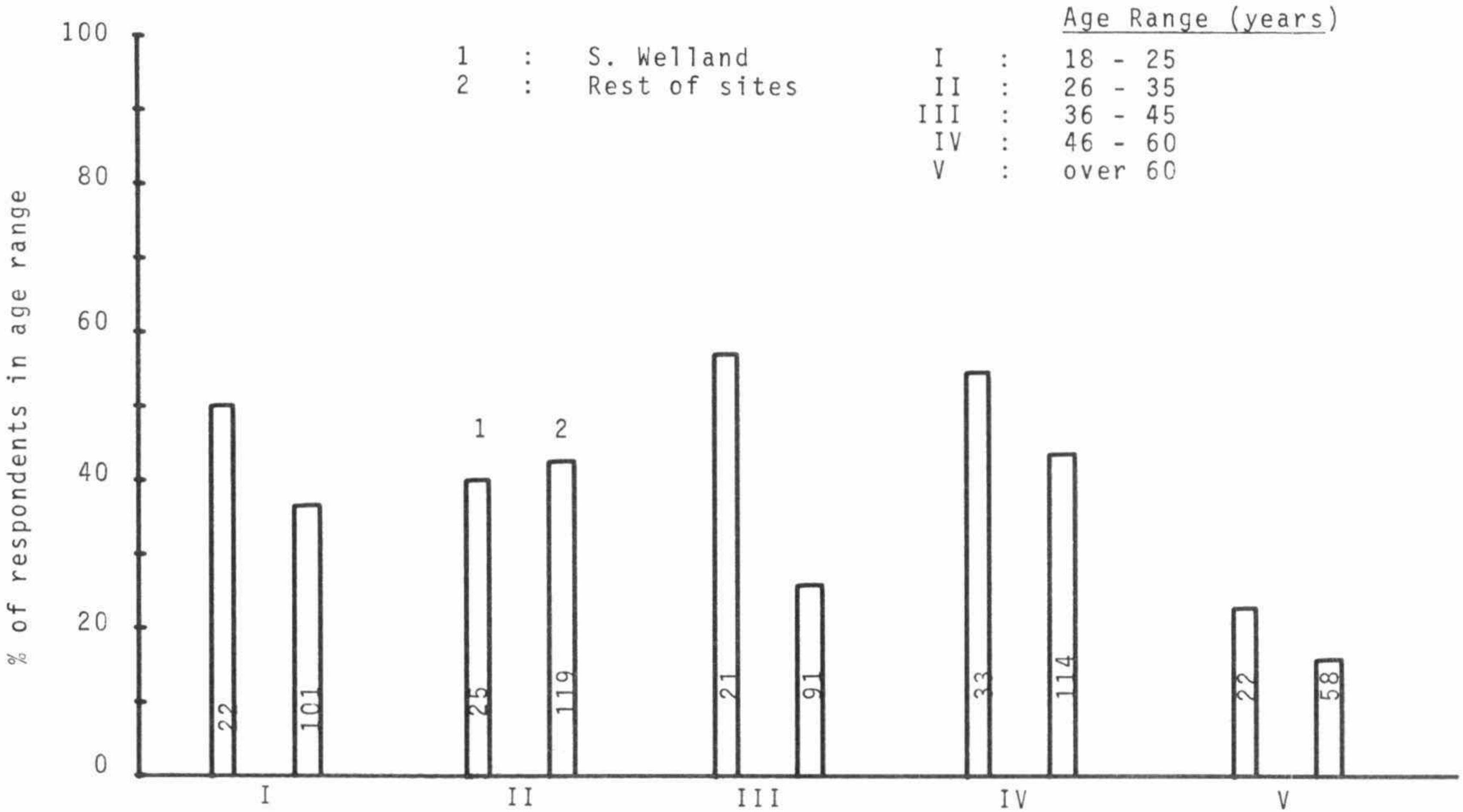



Fig. 39: Disturbed in general by traffic noise (NSANY 2) Cross-tabulated with age of respondents.

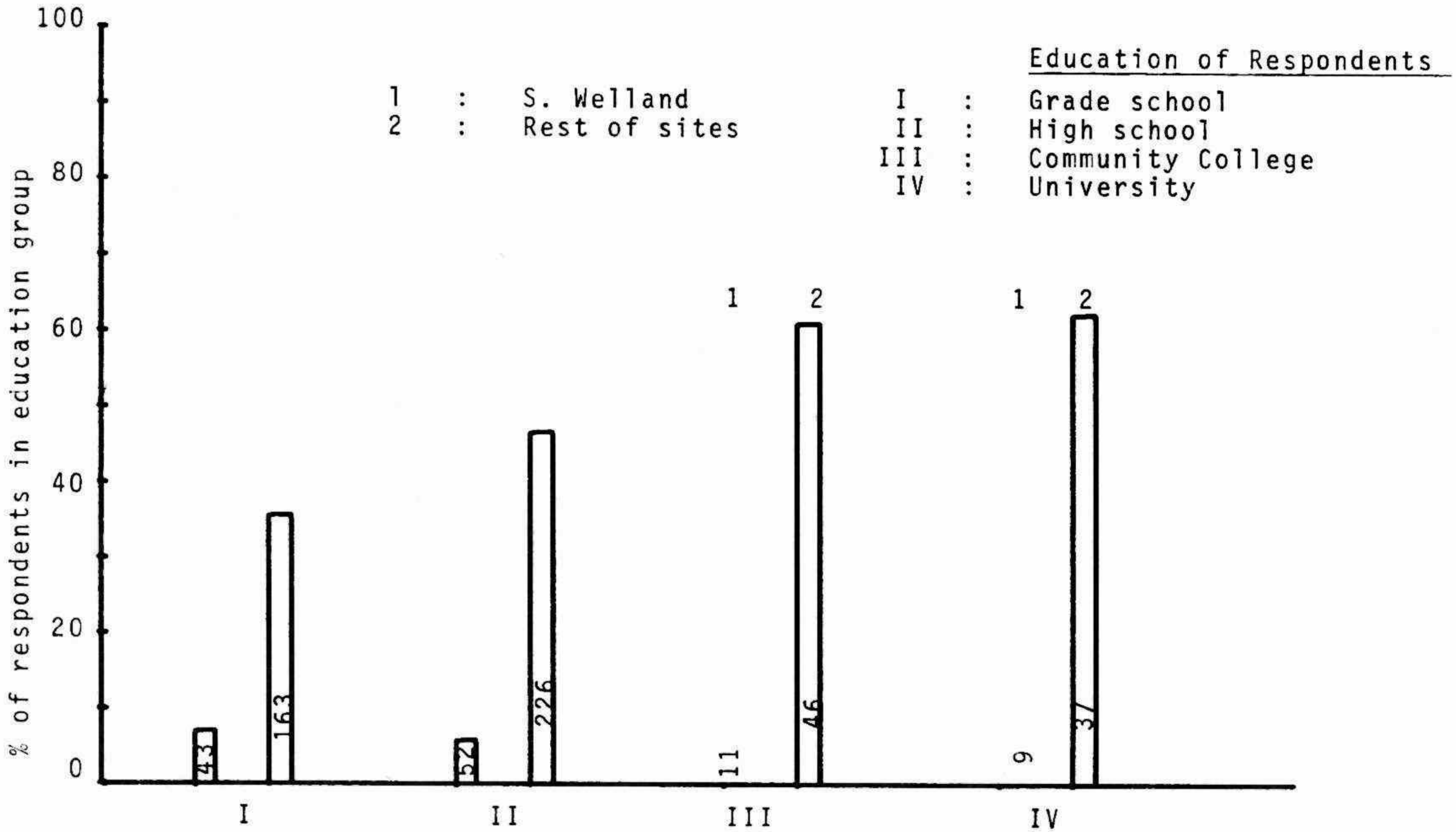



Fig. 40: Disturbed in general by industry noise (NSANY 1) Cross-tabulated with education of respondents.

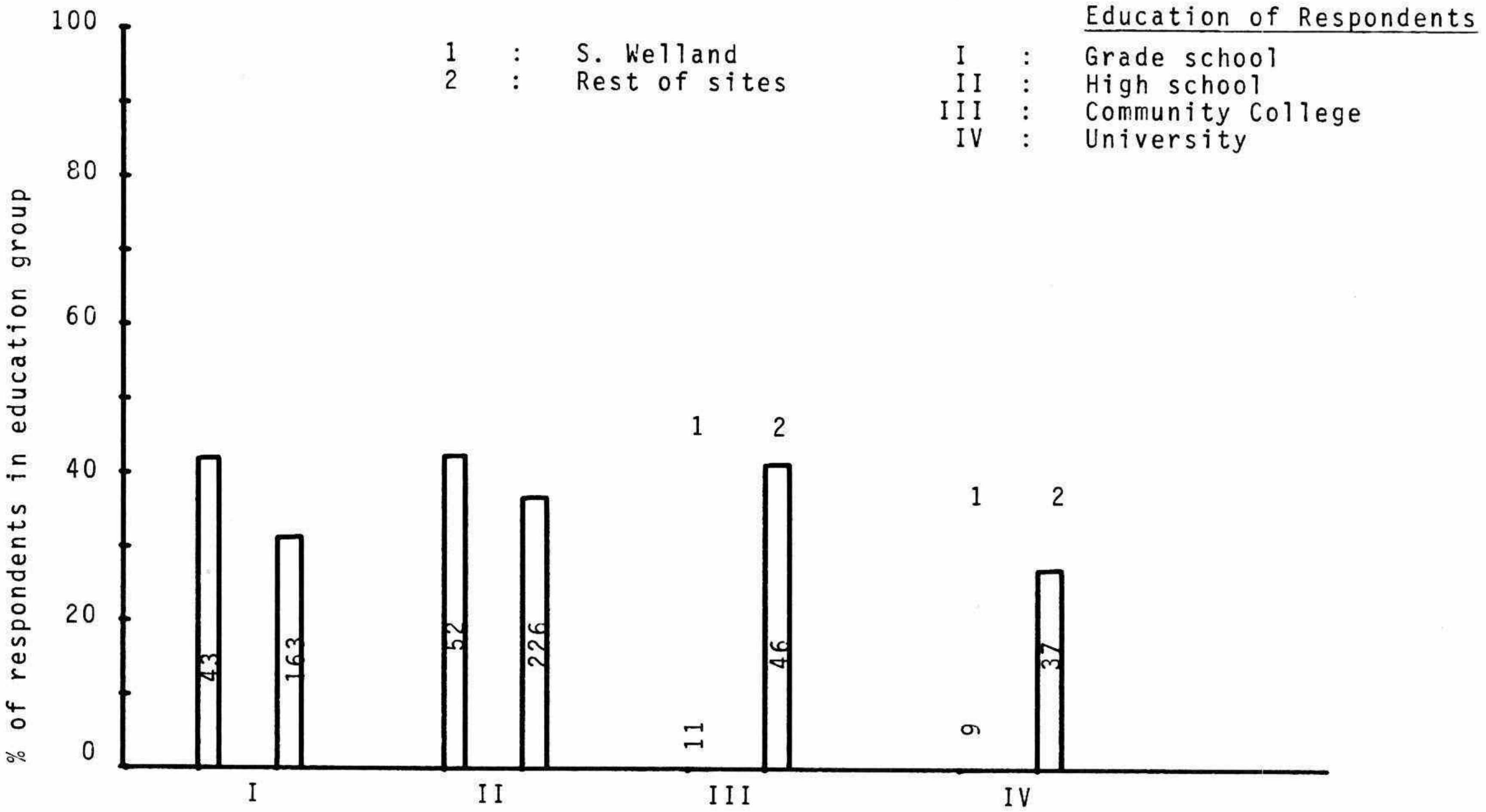



Fig. 41: Disturbed in general by traffic noise (NSANY 2)
Cross-tabulated with education of respondents.

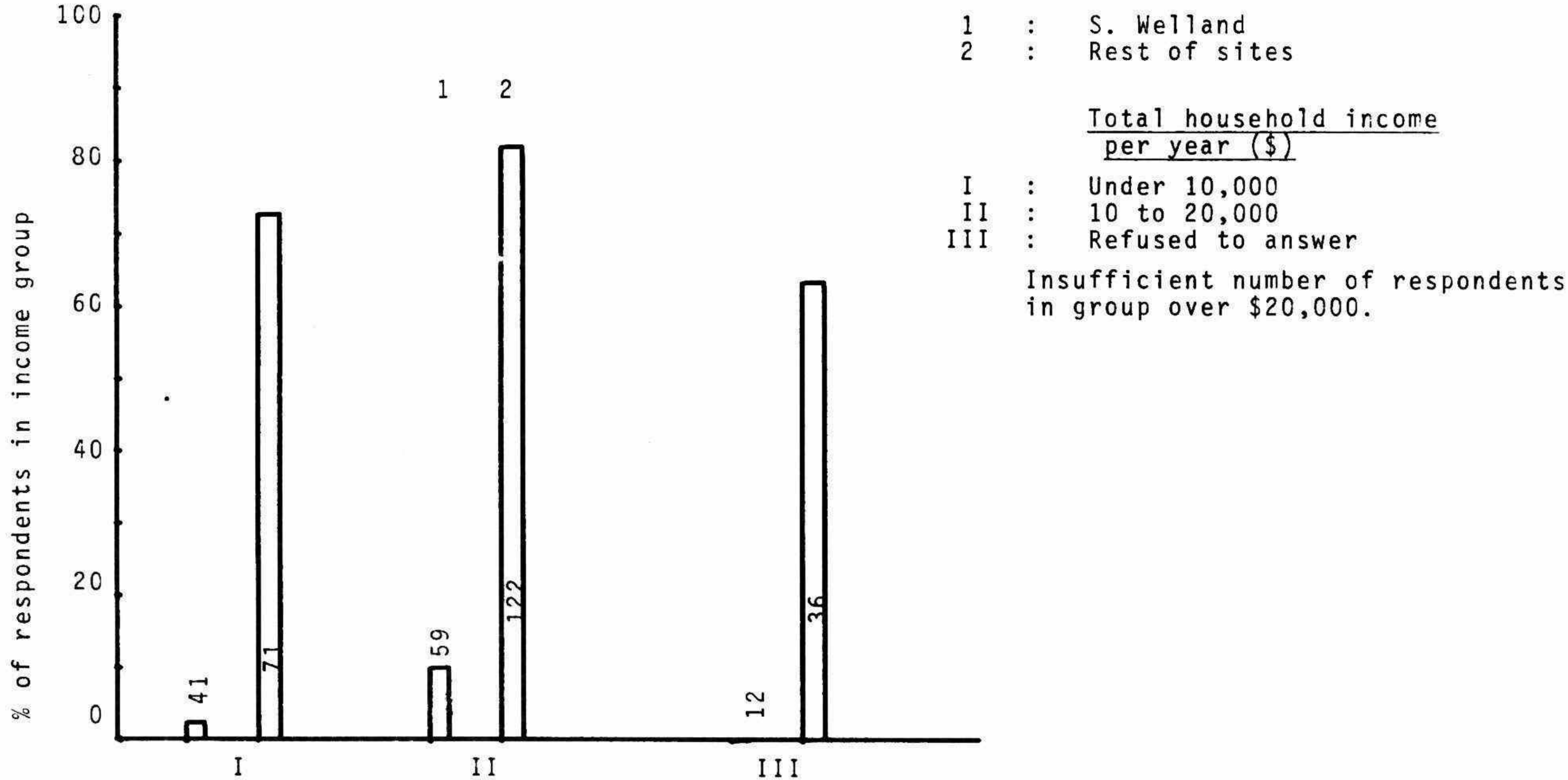



Fig. 42: Disturbed in general by industry noise (NSANY 1)
Cross-tabulated with income of respondents.

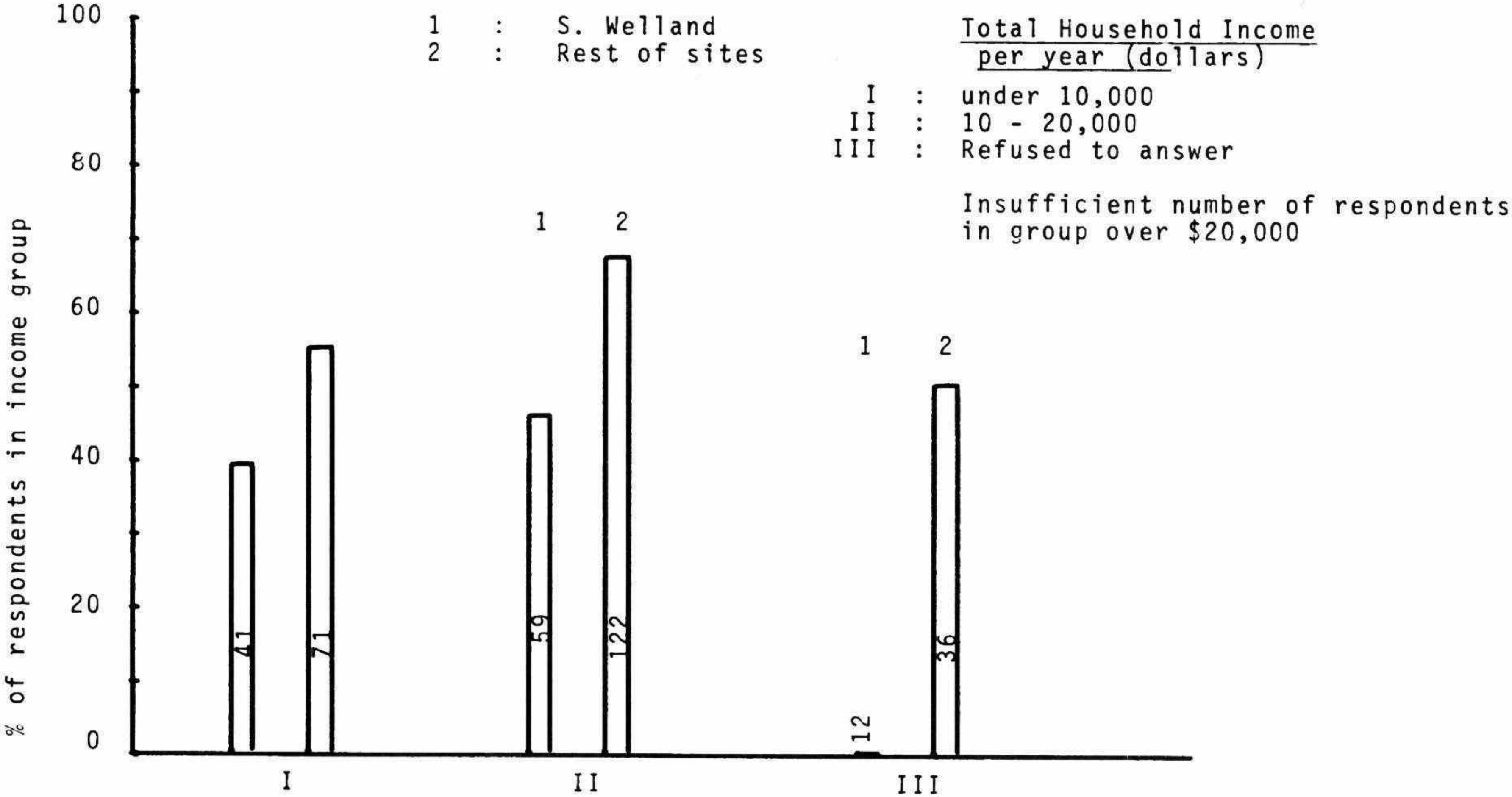



Fig. 43: Disturbed in general by traffic noise (NSANY 2) Cross-tabulated with income of respondents.

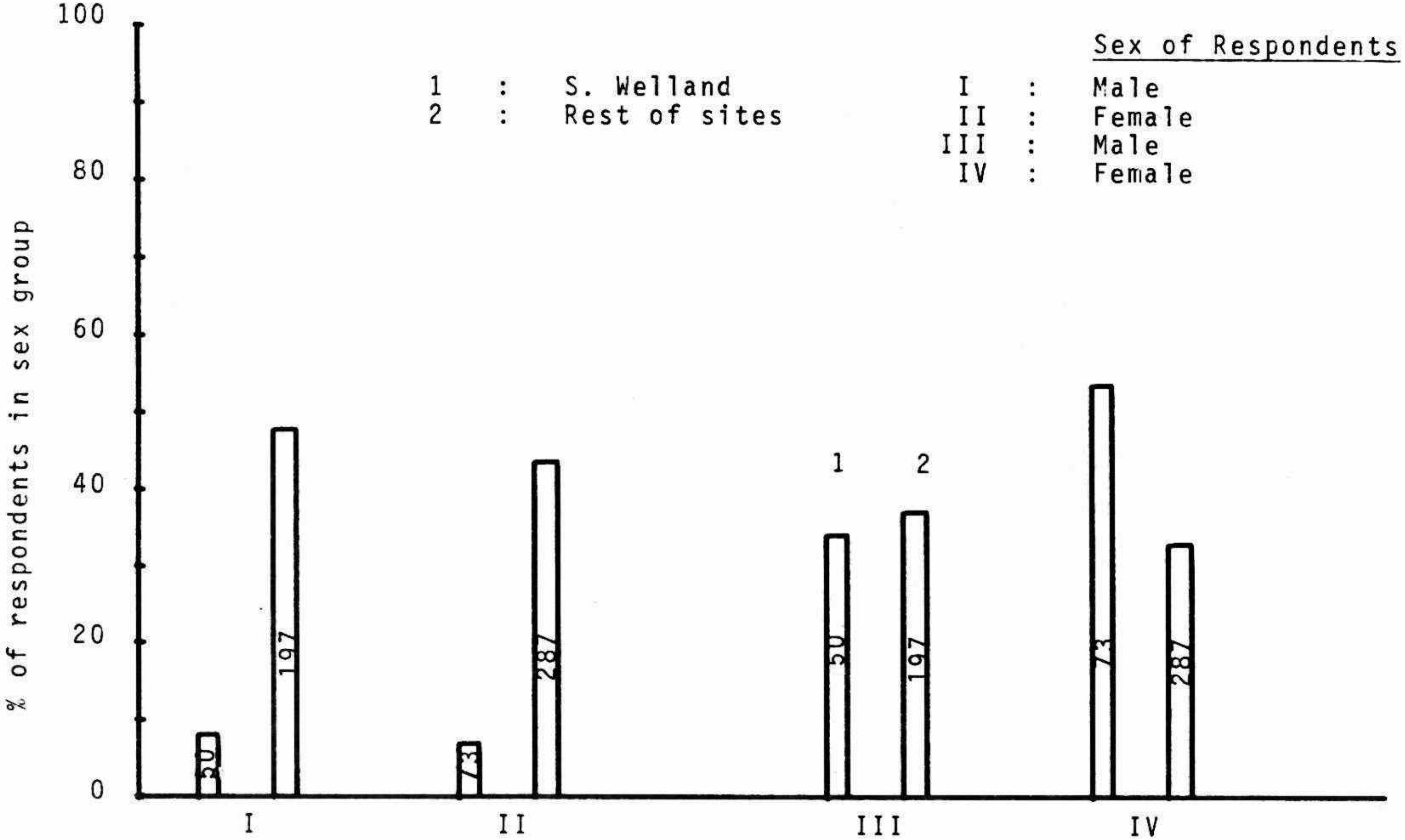
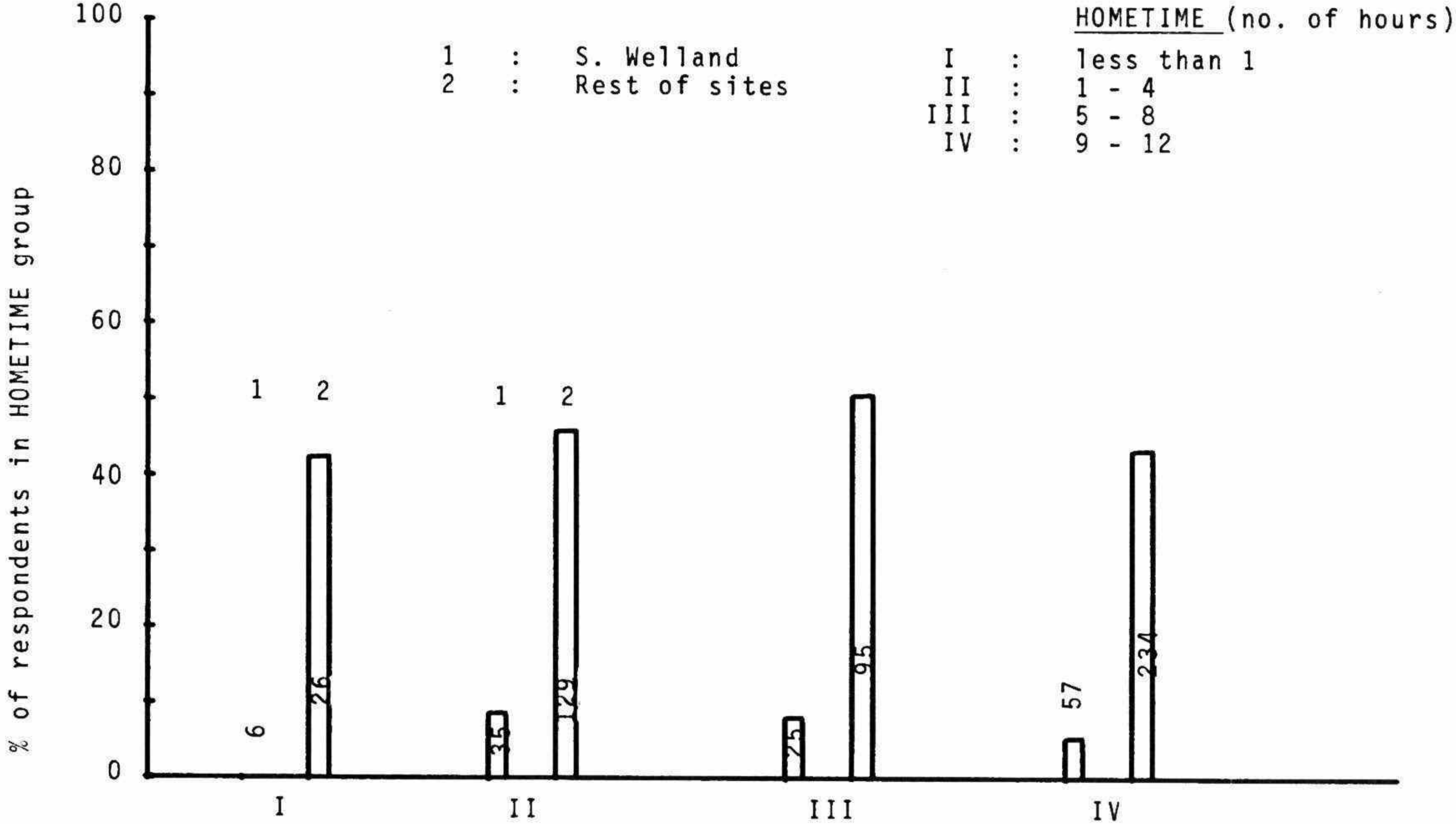



Fig. 44: Disturbed in general by (I, II) Industry noise (NSANY 1)
(III, IV) Traffic noise (NSANY 2)
Cross-tabulated with sex of respondents.




<u>Fig. 45</u>: Disturbed in general by industry noise (NSANY 1) Cross-tabulated with amount of time spent at home during weekday daytime (HOMETIME)

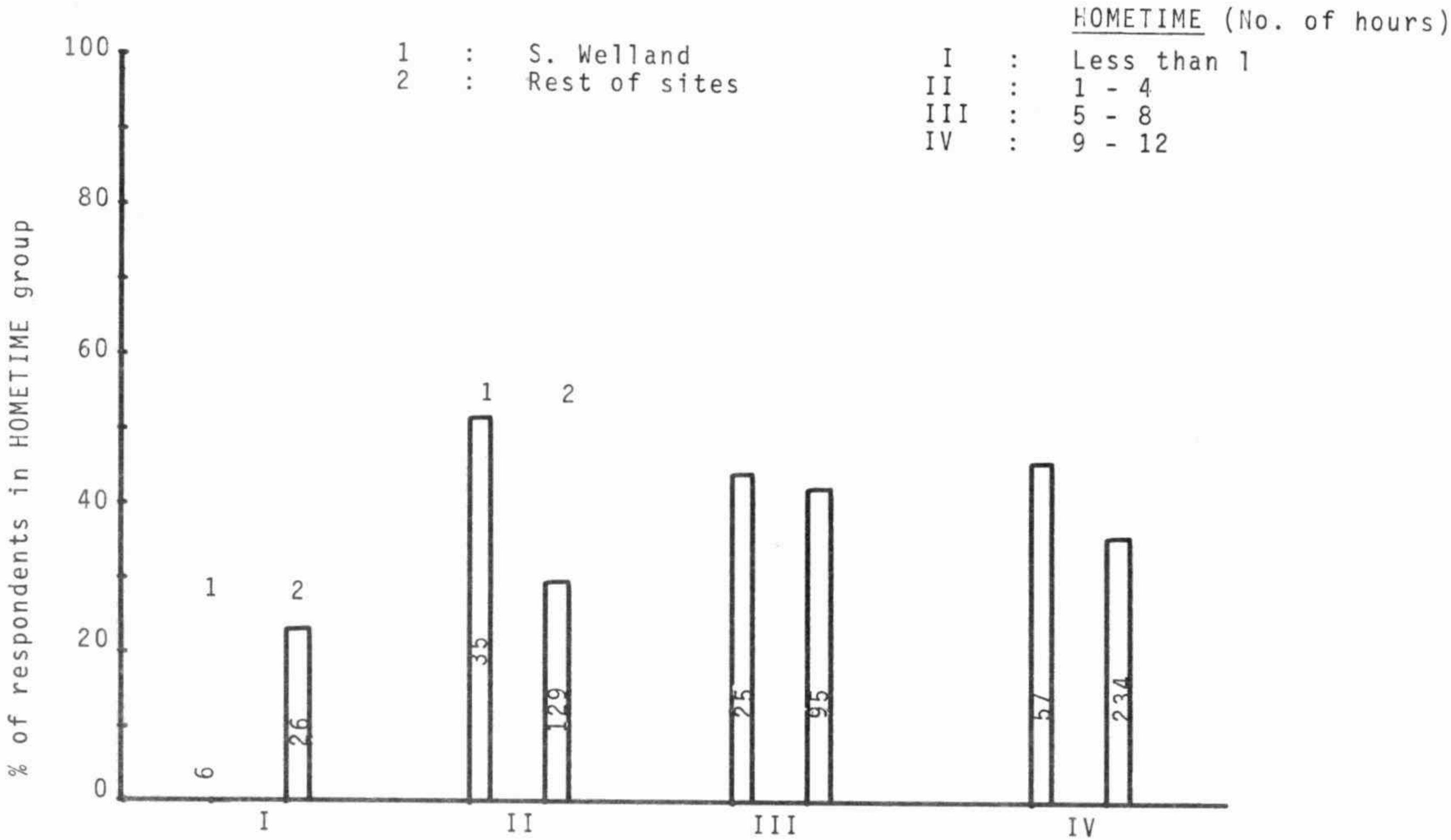



Fig. 46: Disturbed in general by traffic noise (NSANY 2) Cross-tabulated with amount of time spent at home during weekday daytime (HOMETIME)

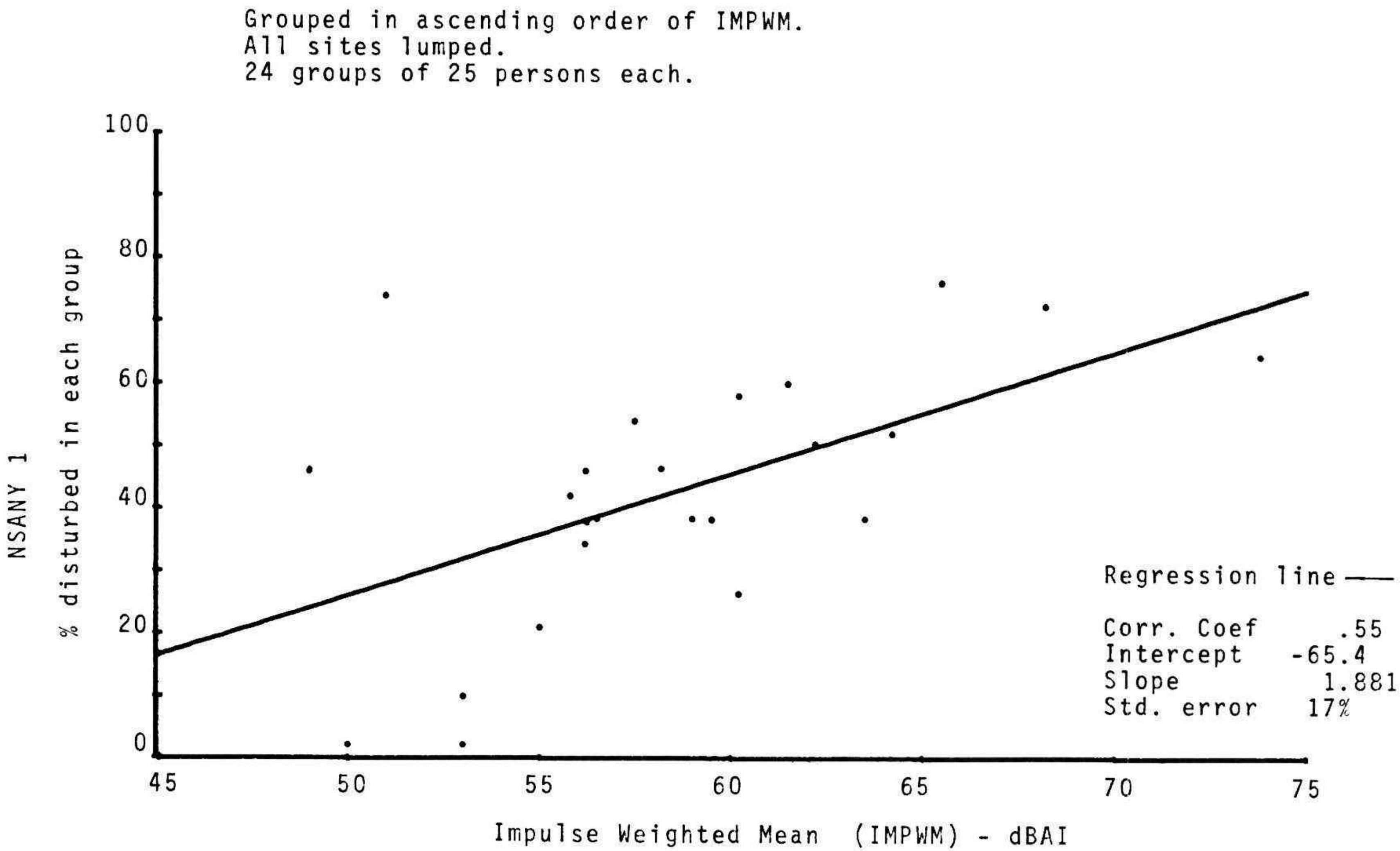



Fig. 47: Regression of NSANY 1 on IMPWM

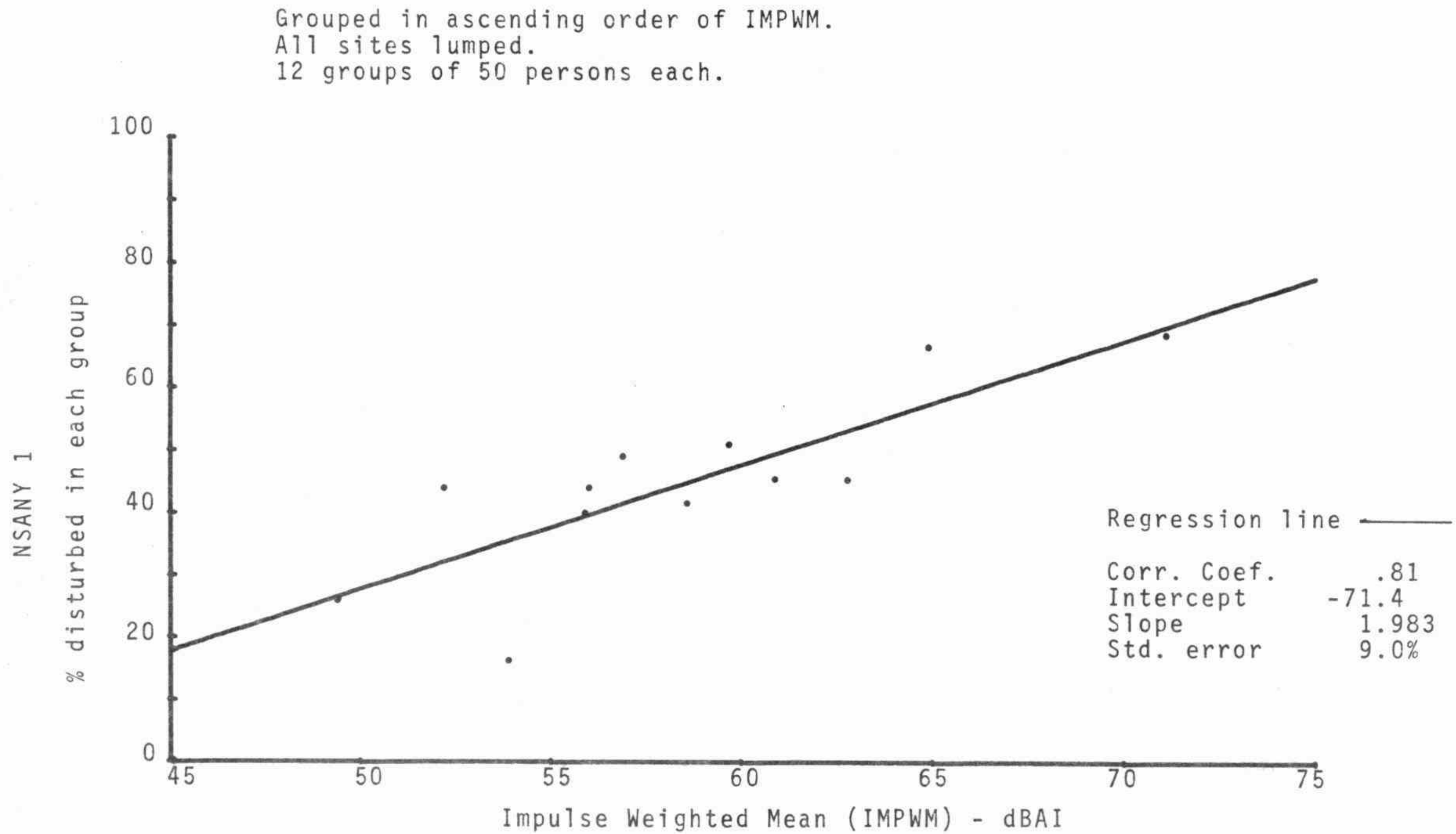



Fig. 48: Regression of NSANY 1 on IMPWM

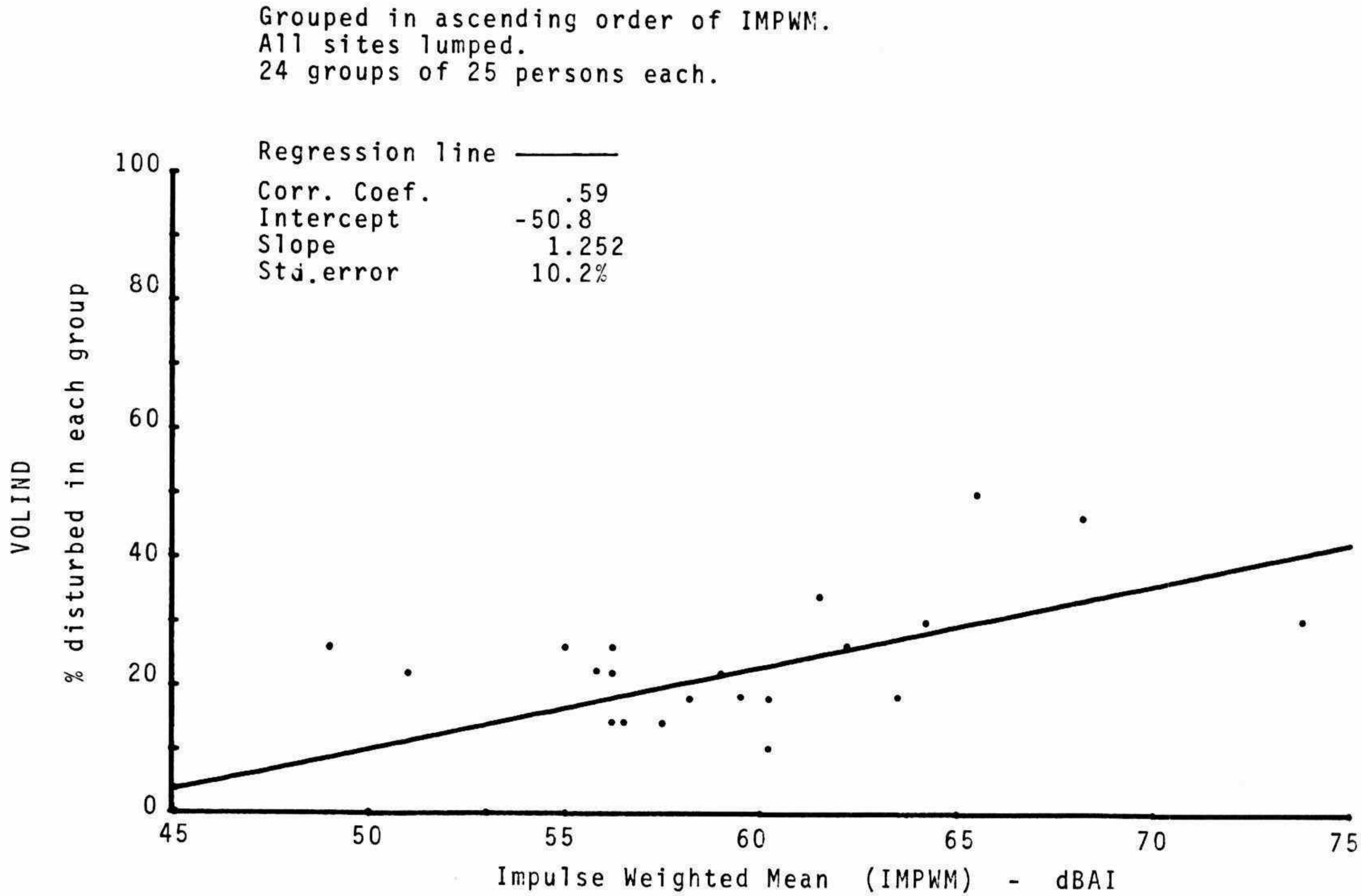



Fig. 49: Regression of VOLIND on IMPWM

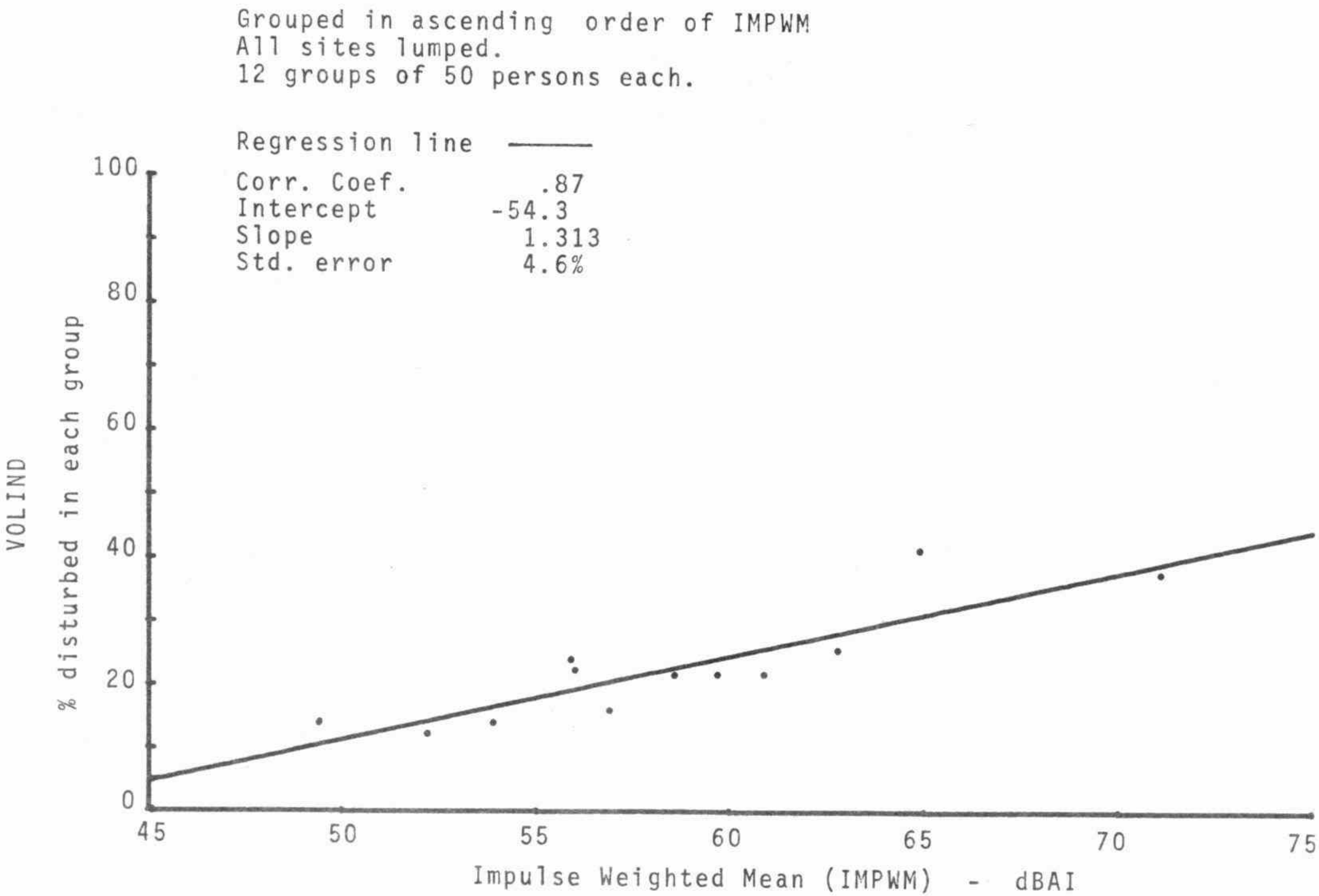



Fig. 50: Regression of VOLIND on IMPWM

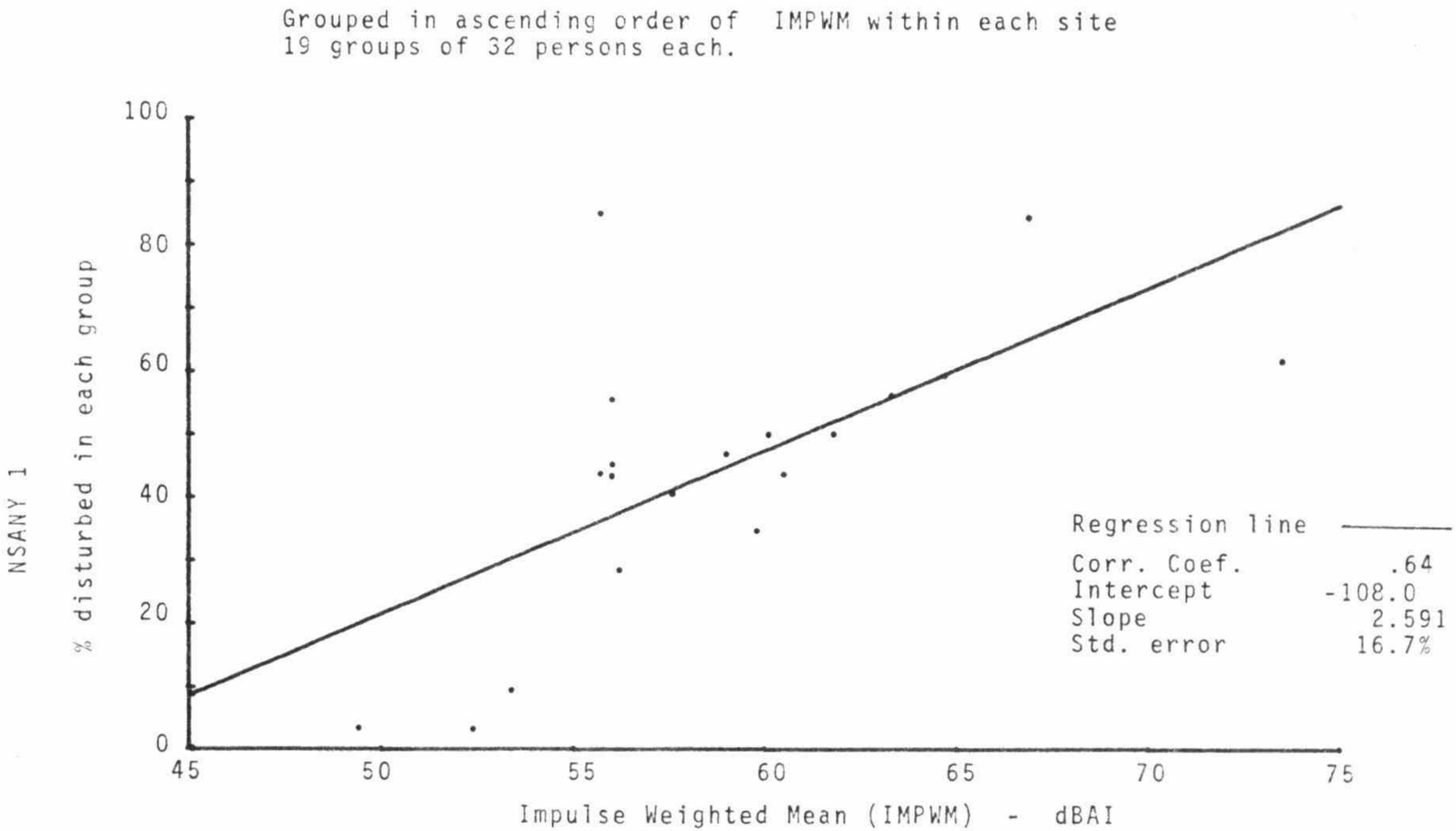



Fig. 51: Regression of NSANY 1 on IMPWM

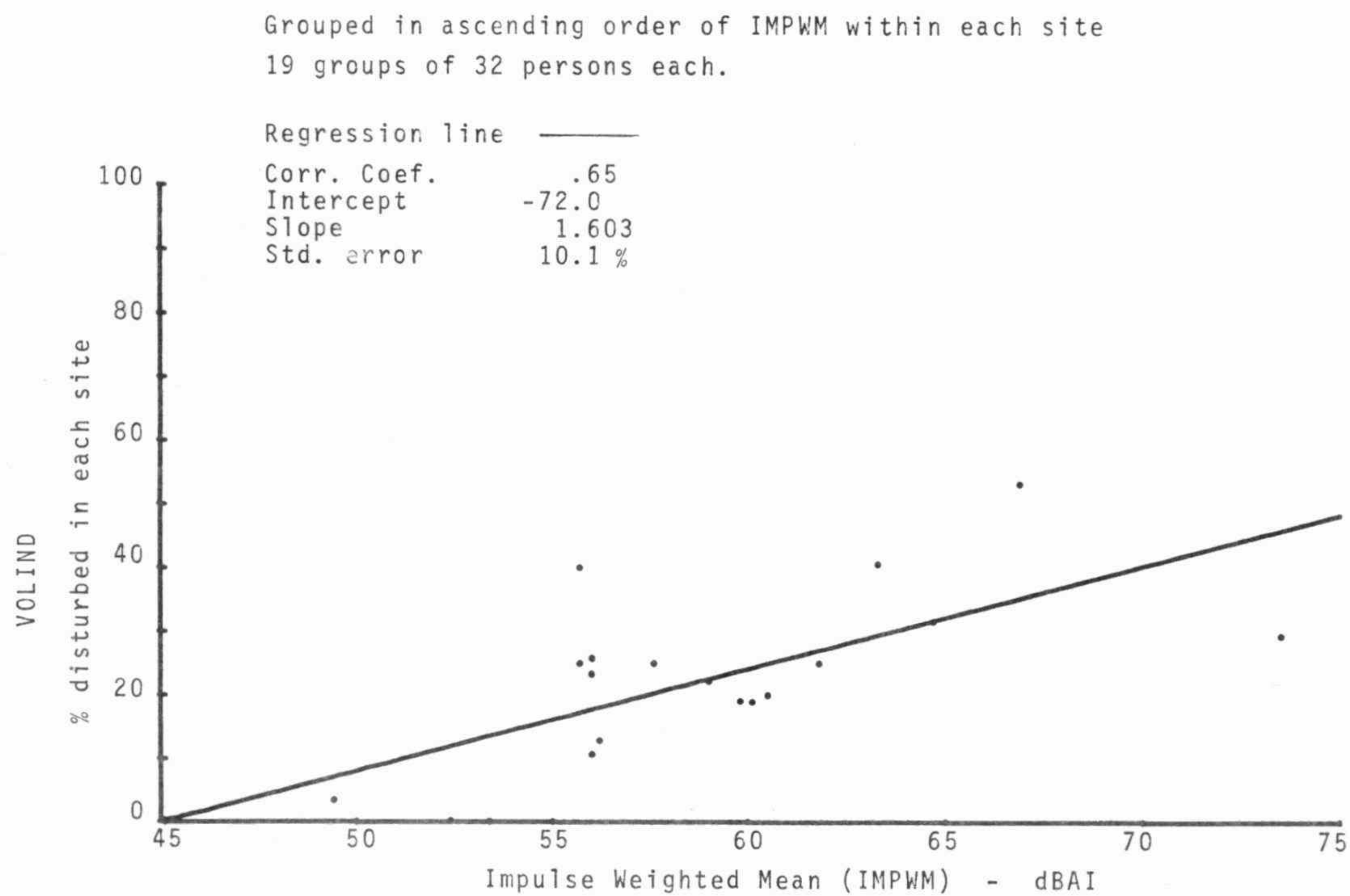



Fig. 52: Regression of VOLIND on IMPWM

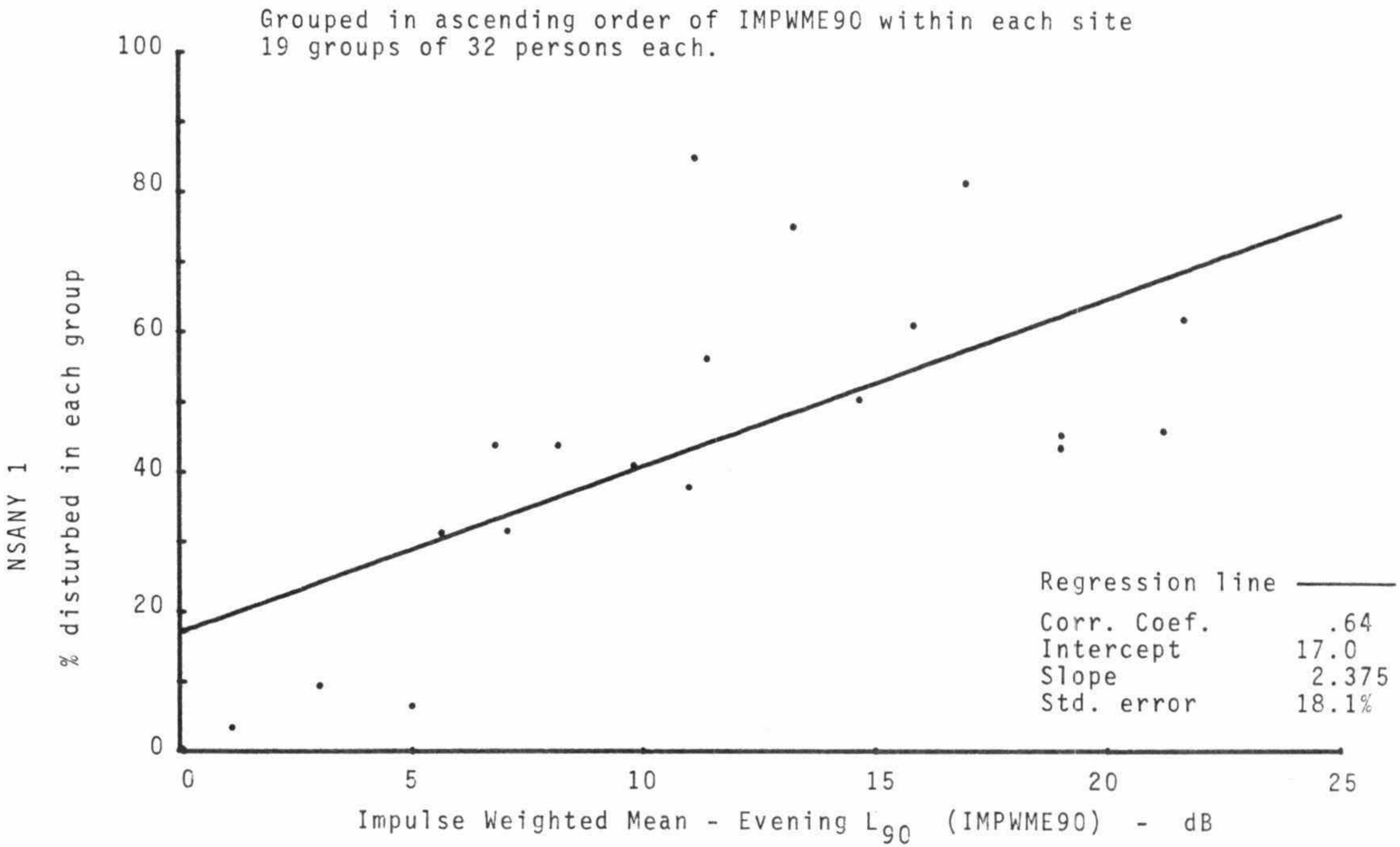



Fig. 53: Regression of NSANY 1 on IMPWME90

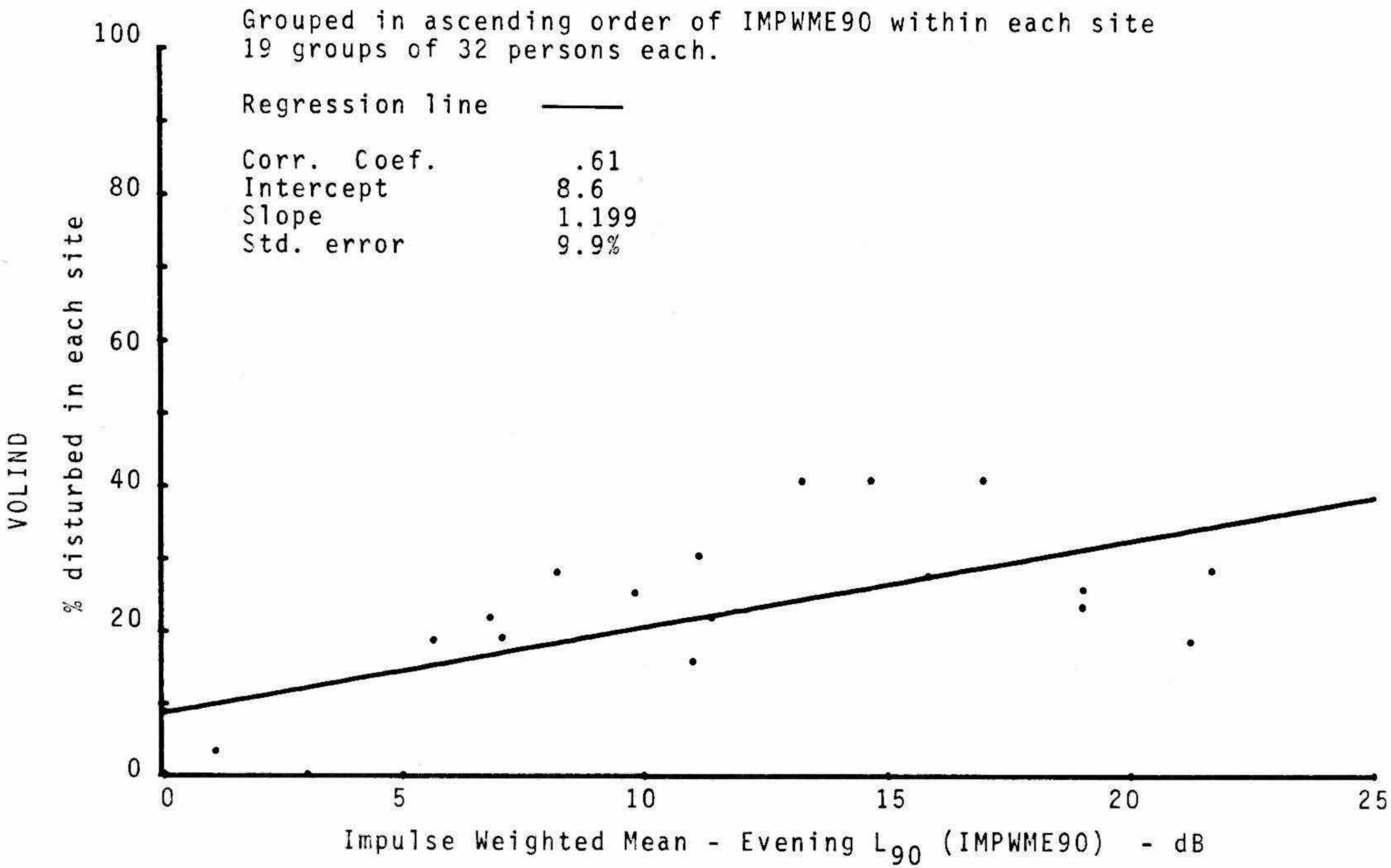



Fig. 54: Regression of VOLIND on IMPWME90

Grouped in ascending order of IMPWMSLQ within each site
19 groups of 32 persons each.

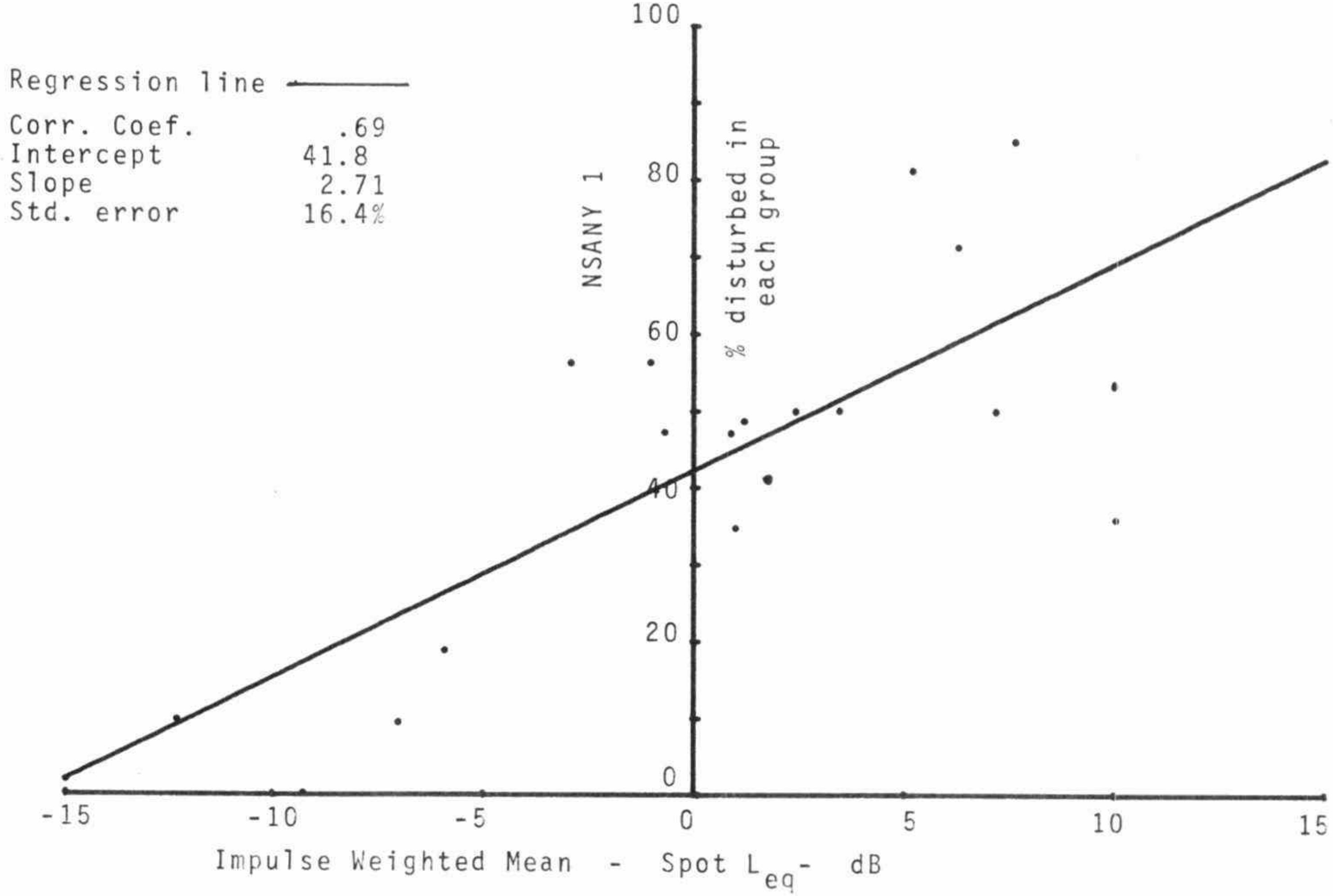



Fig. 55: Regression of NSANY 1 on IMPWMSLQ

Grouped in ascending order of IMPWMSLQ within each site
19 groups of 32 persons each.

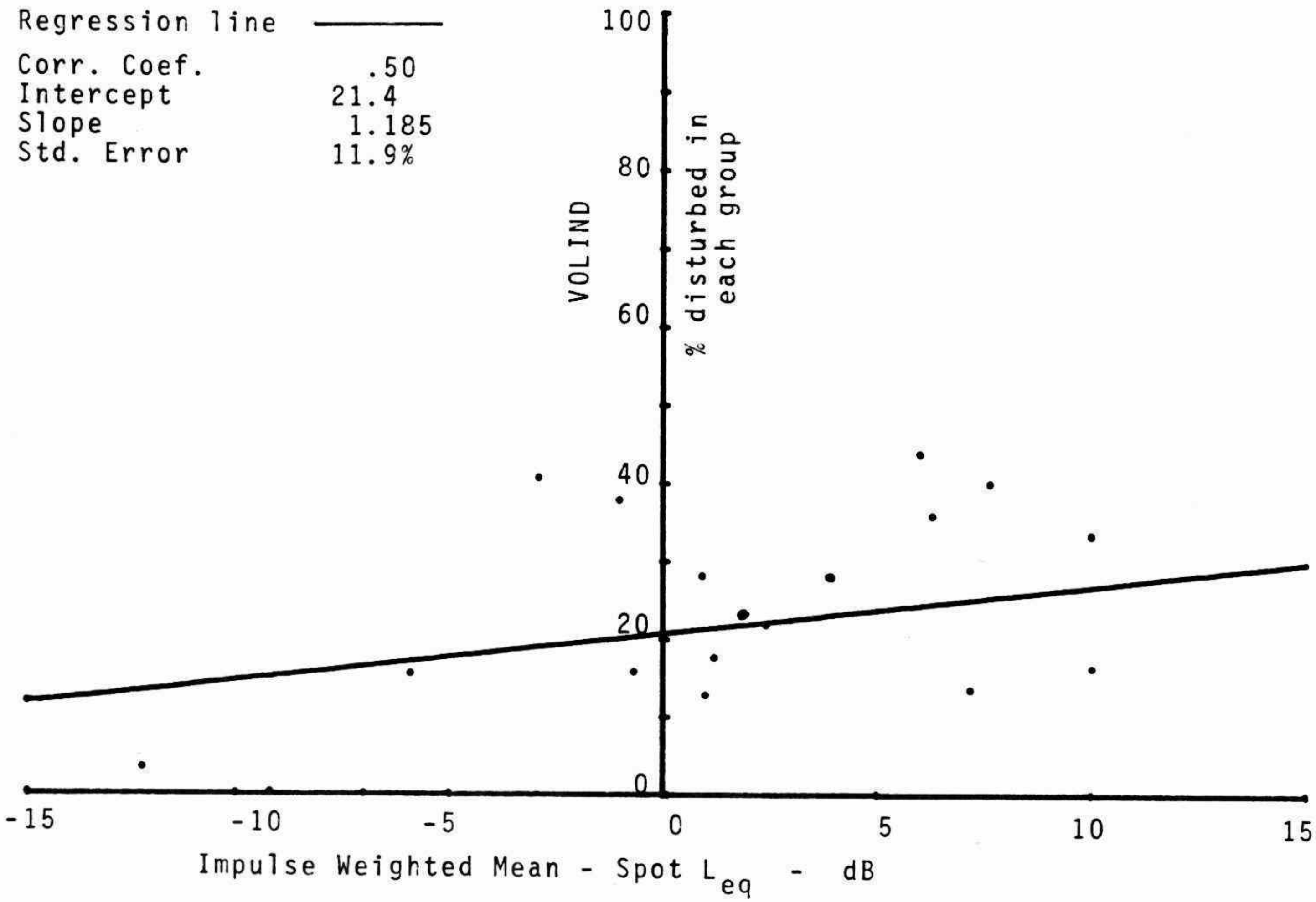
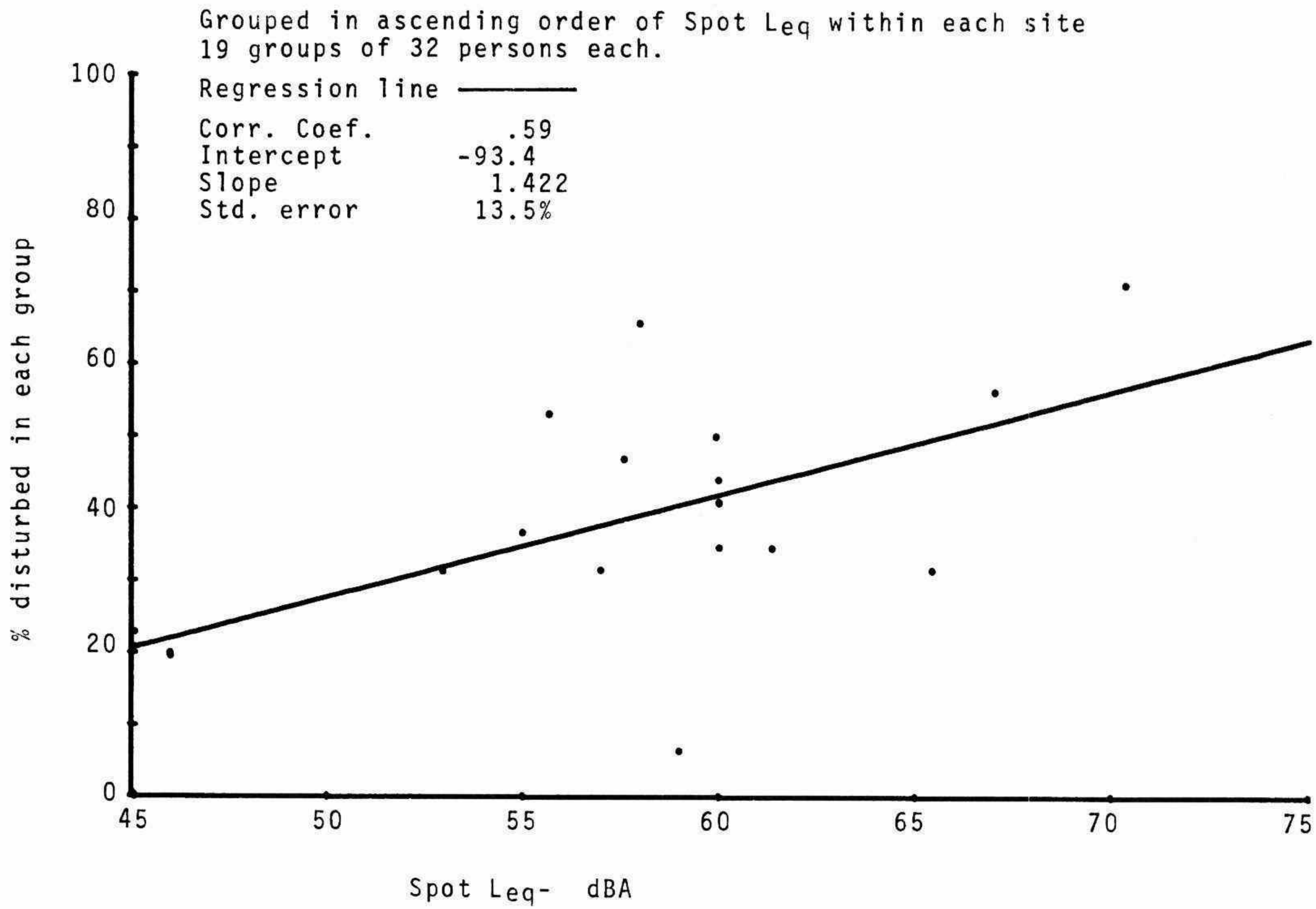



Fig. 56: Regression of VOLIND on IMPWMSLQ




<u>Fig. 57</u>: Regression of NSANY 2 on Spot $L_{eq}$

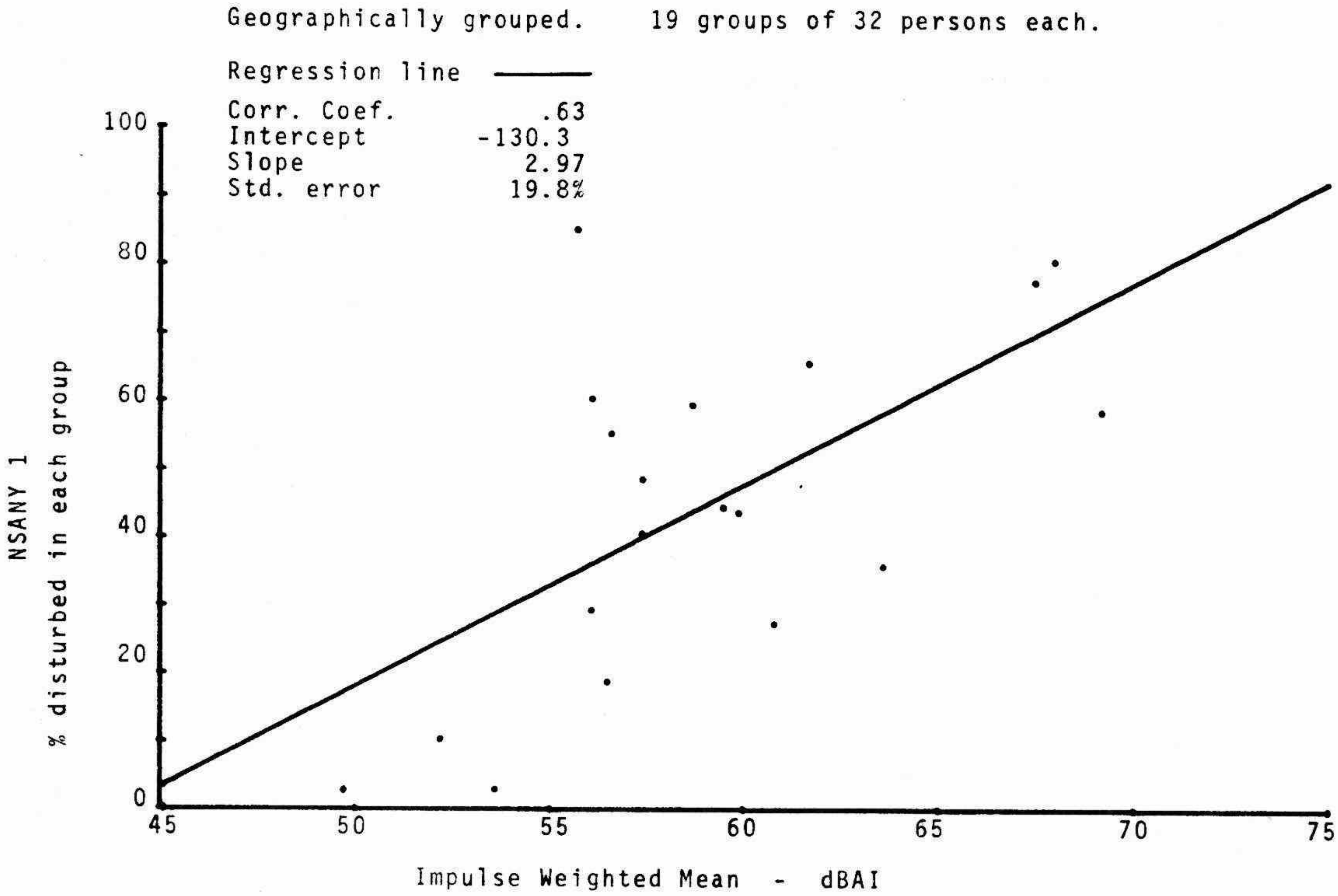



Fig. 58: Regression of NSANY 1 on IMPWM

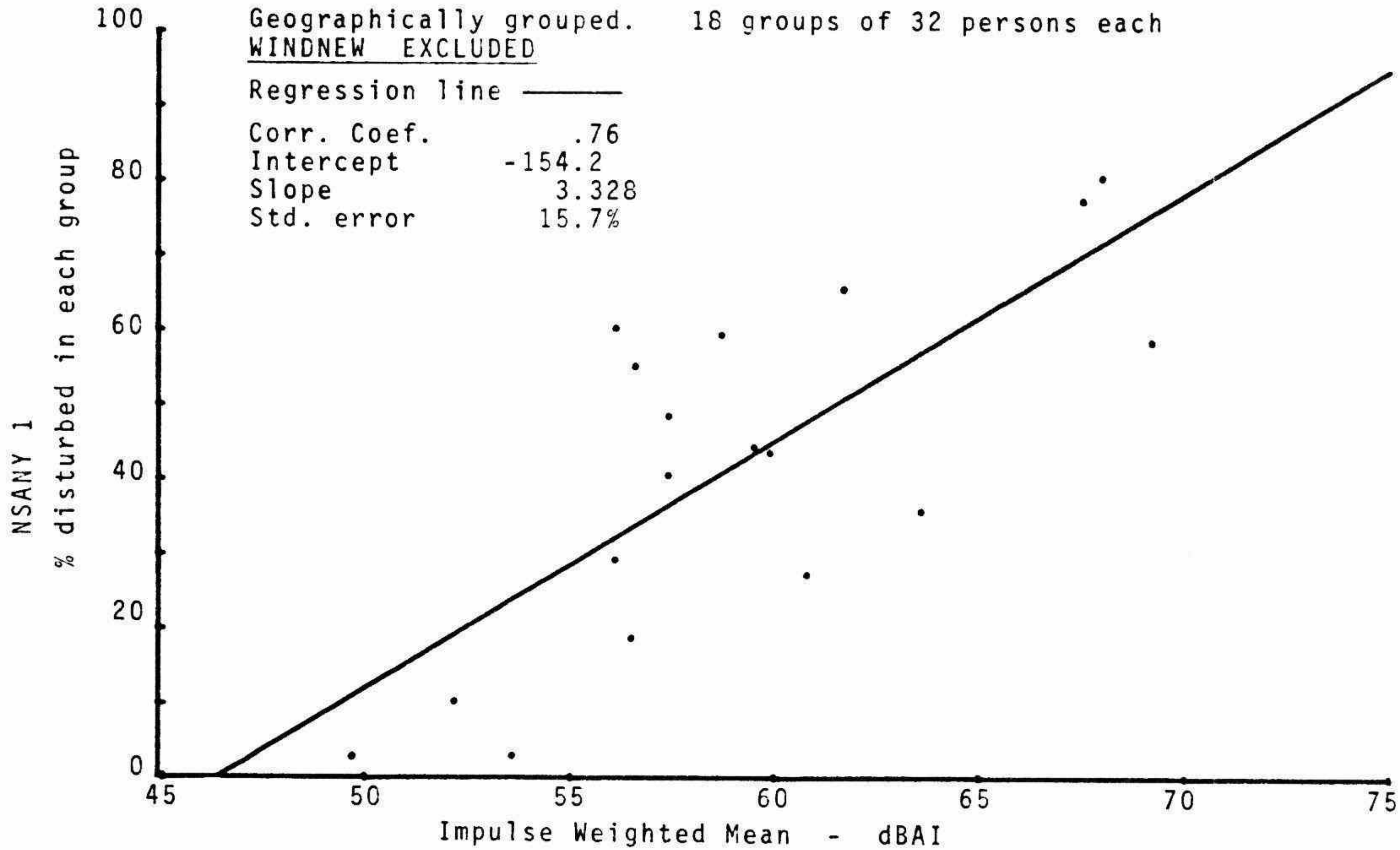



Fig. 59: Regression of NSANY 1 on IMPWM

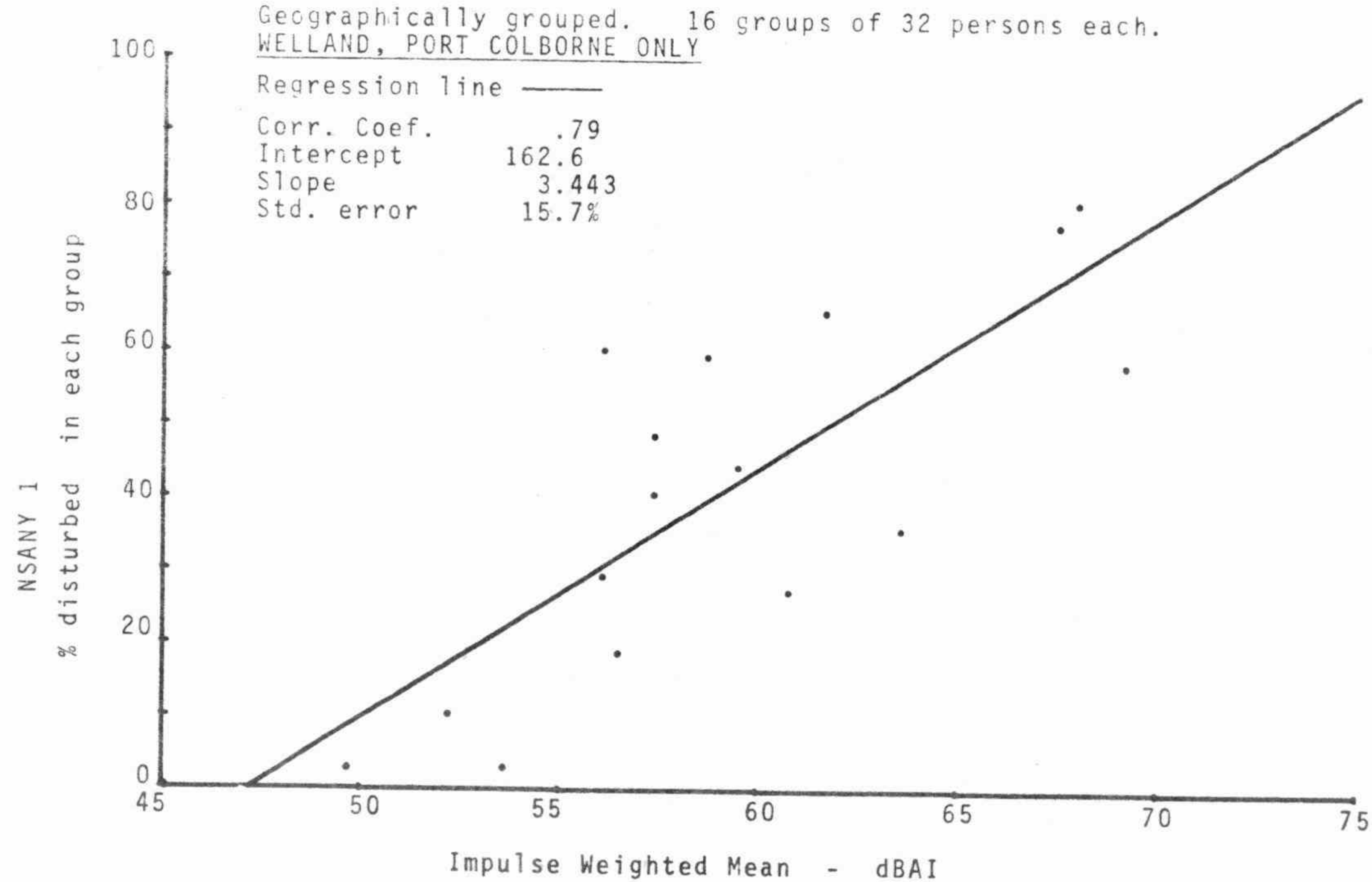



Fig. 60: Regression of NSANY 1 on IMPWM

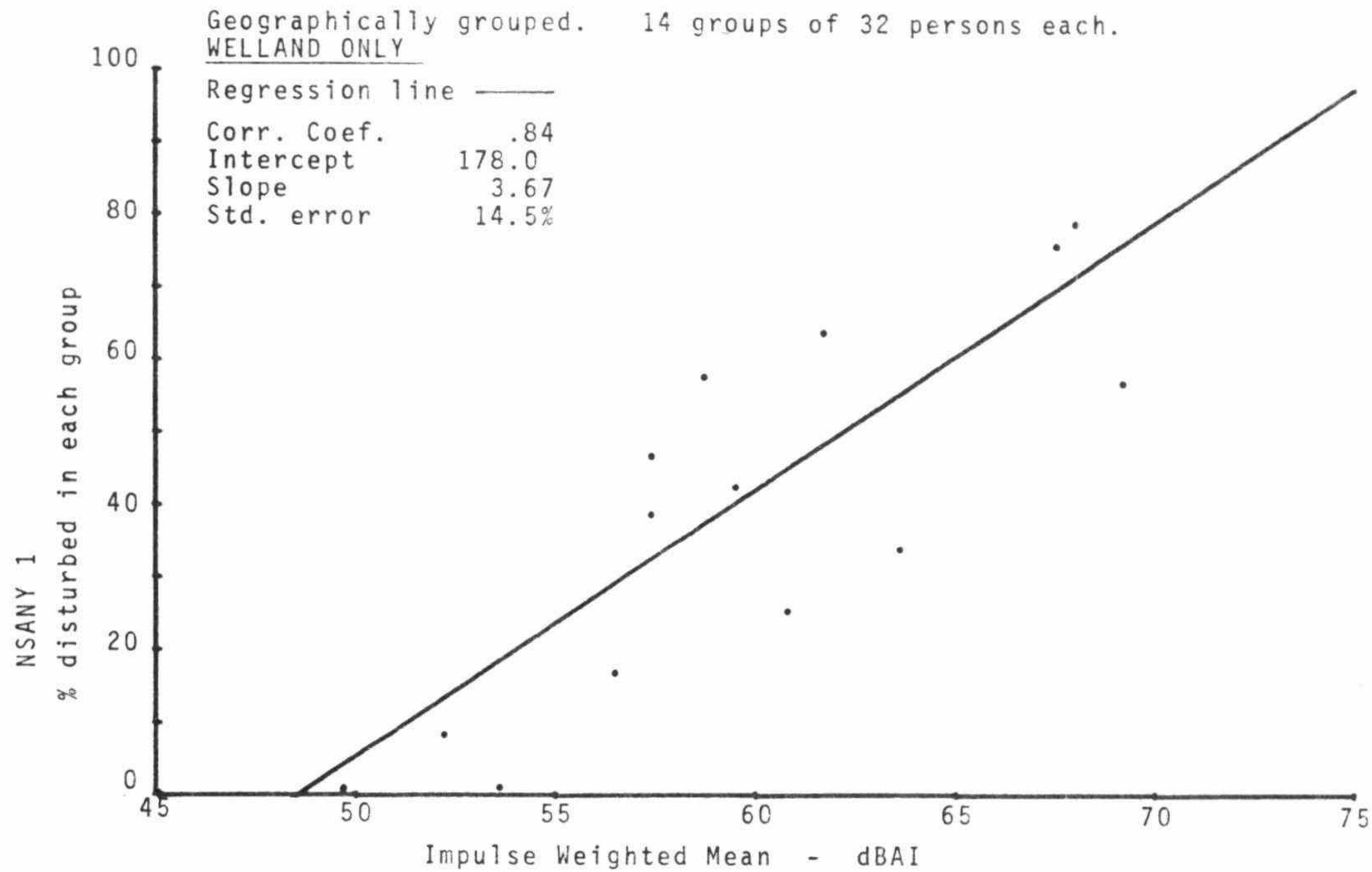



Fig. 61: Regression of NSANY 1 on IMPWM

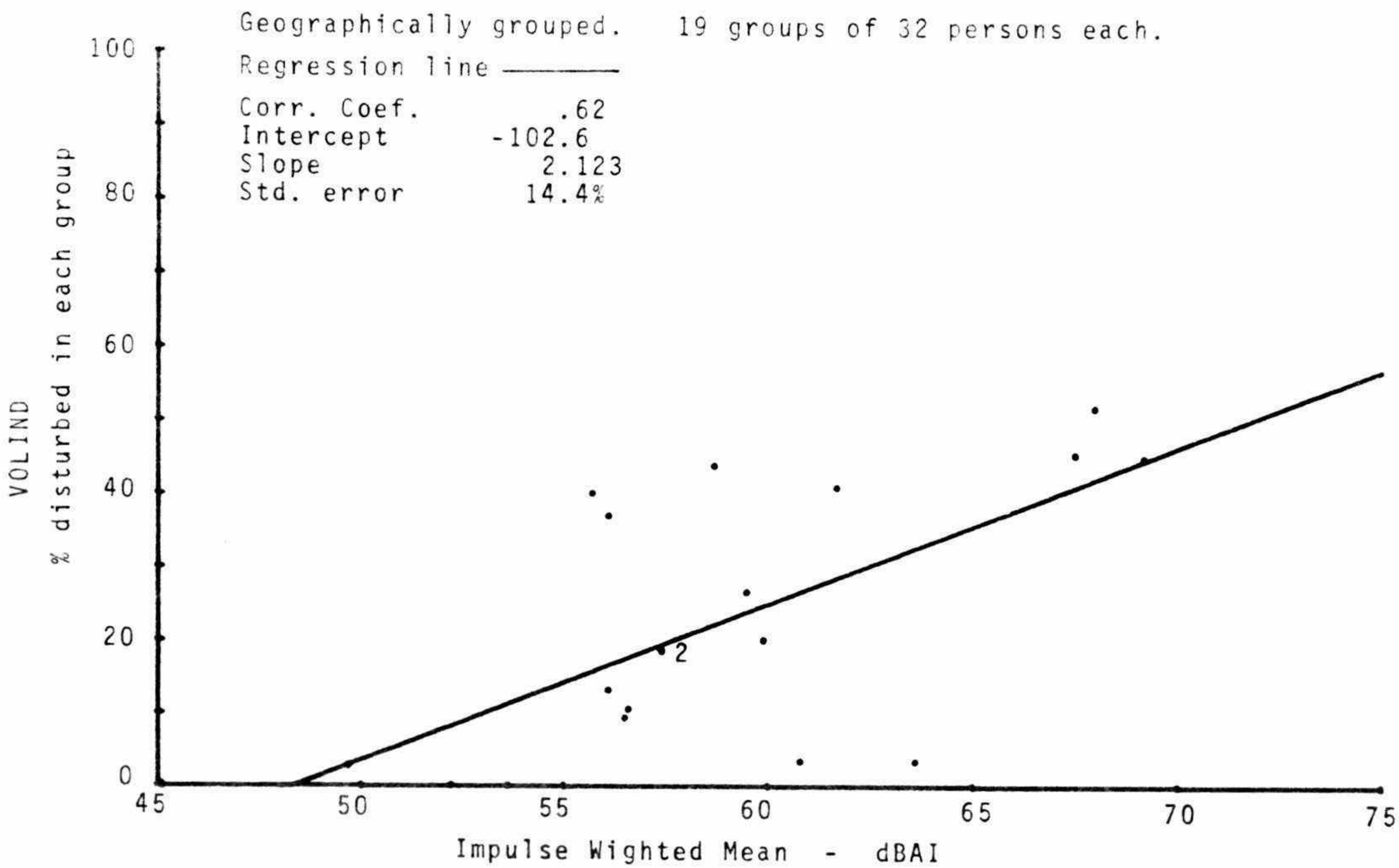



Fig. 62: Regression of VOLIND on IMPWM

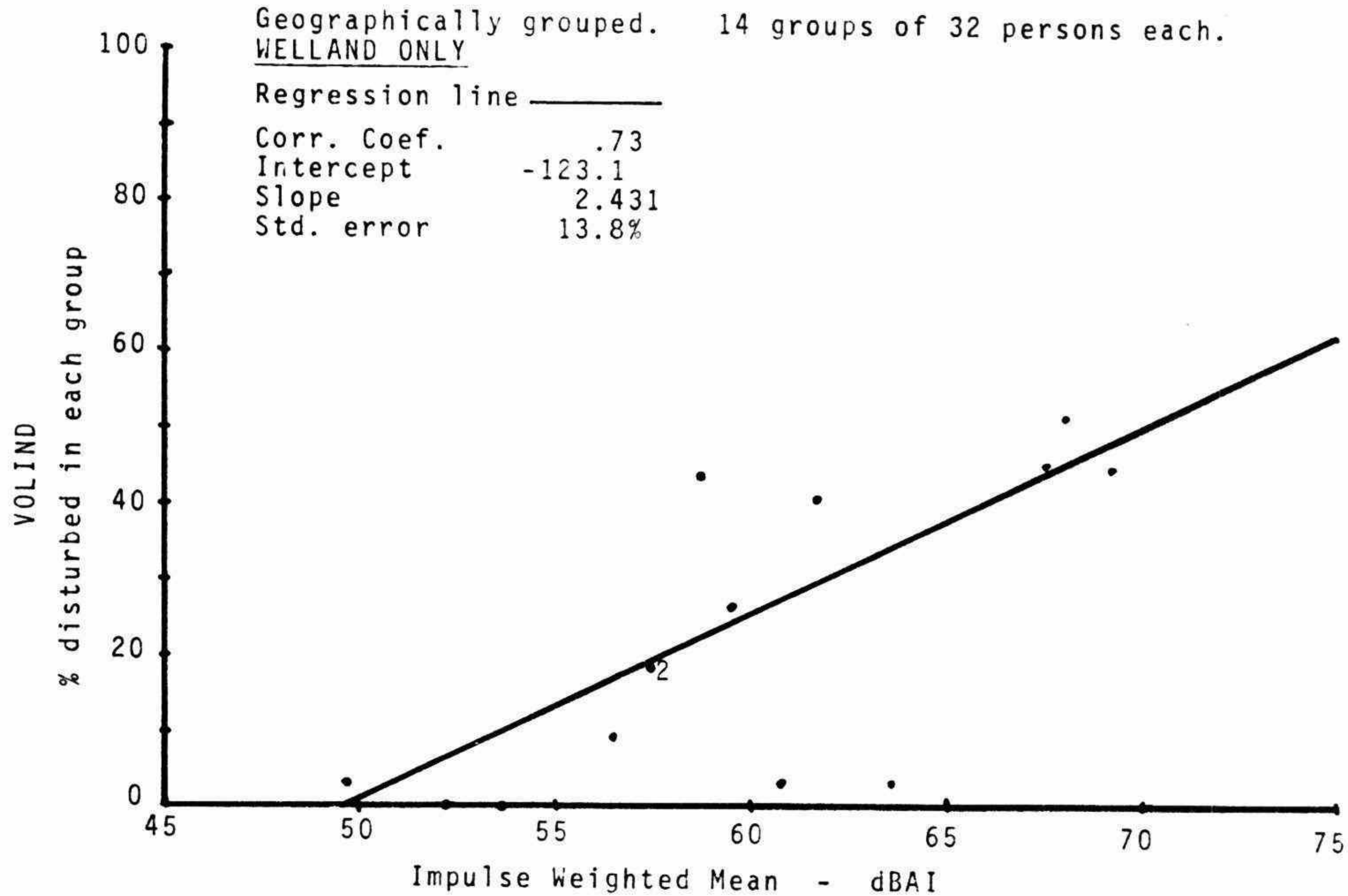



Fig. 63: Regression of VOLIND on IMPWM

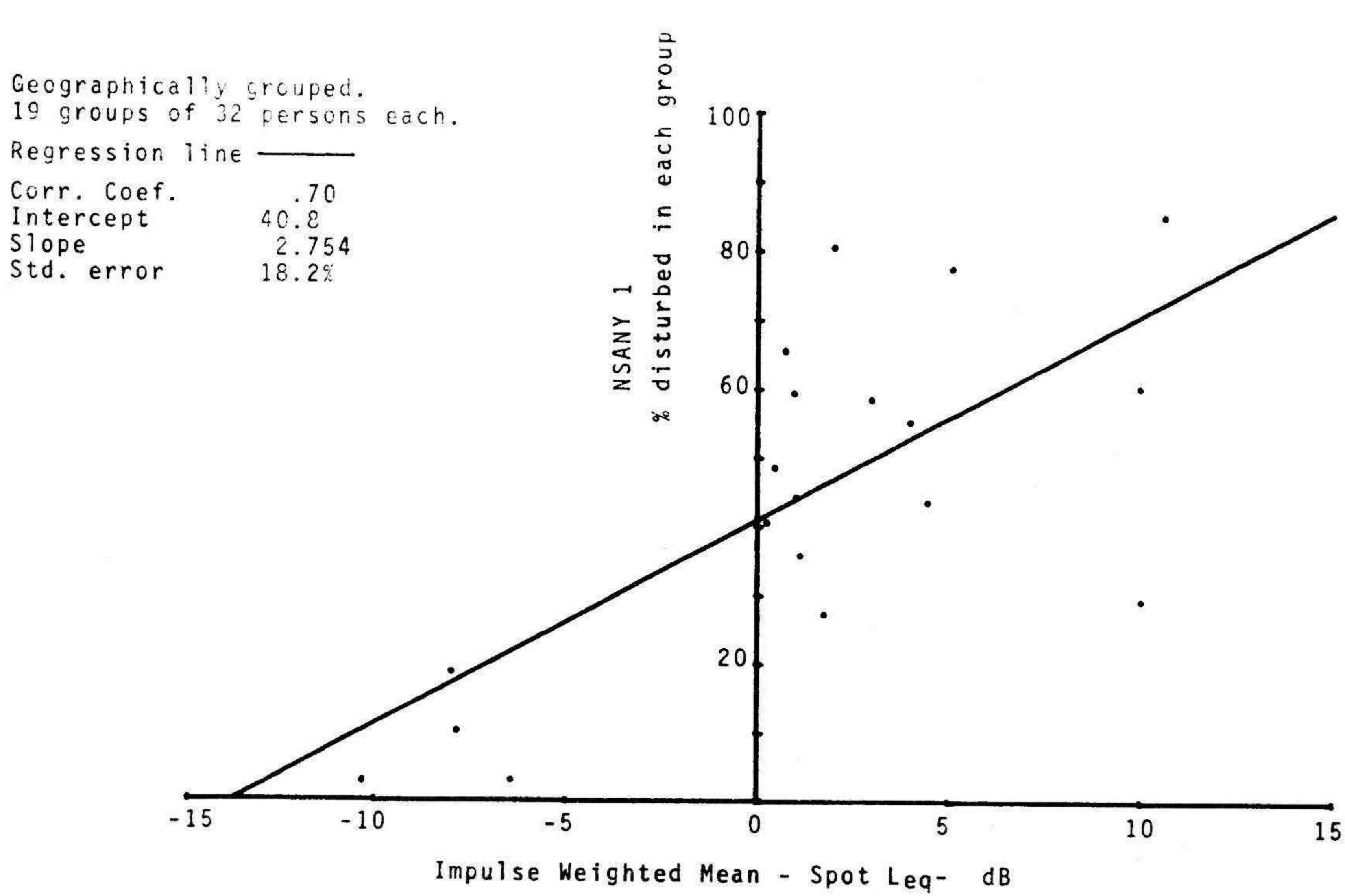



Fig. 64: Regression of NSANY 1 on IMPWMSLQ

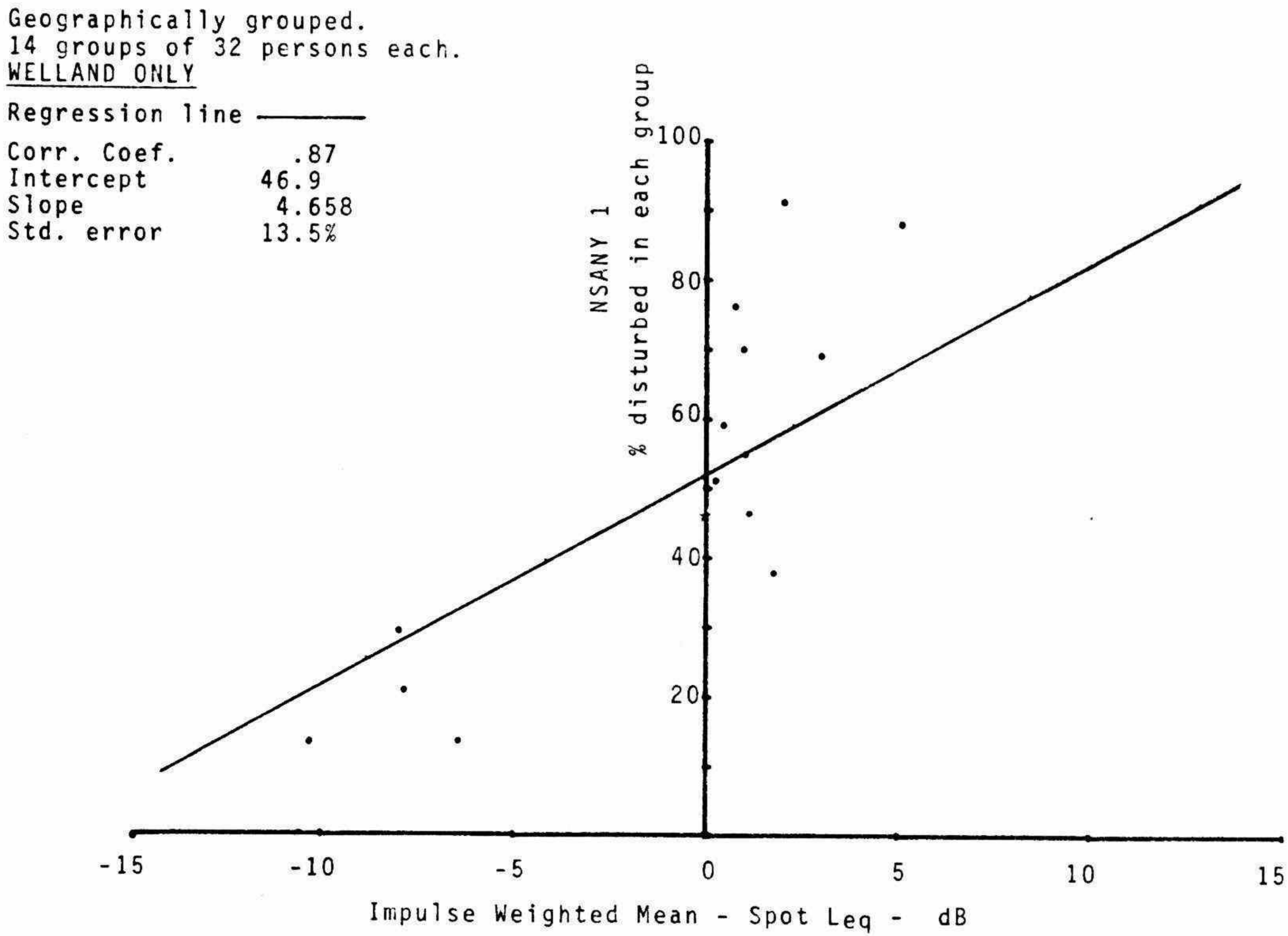
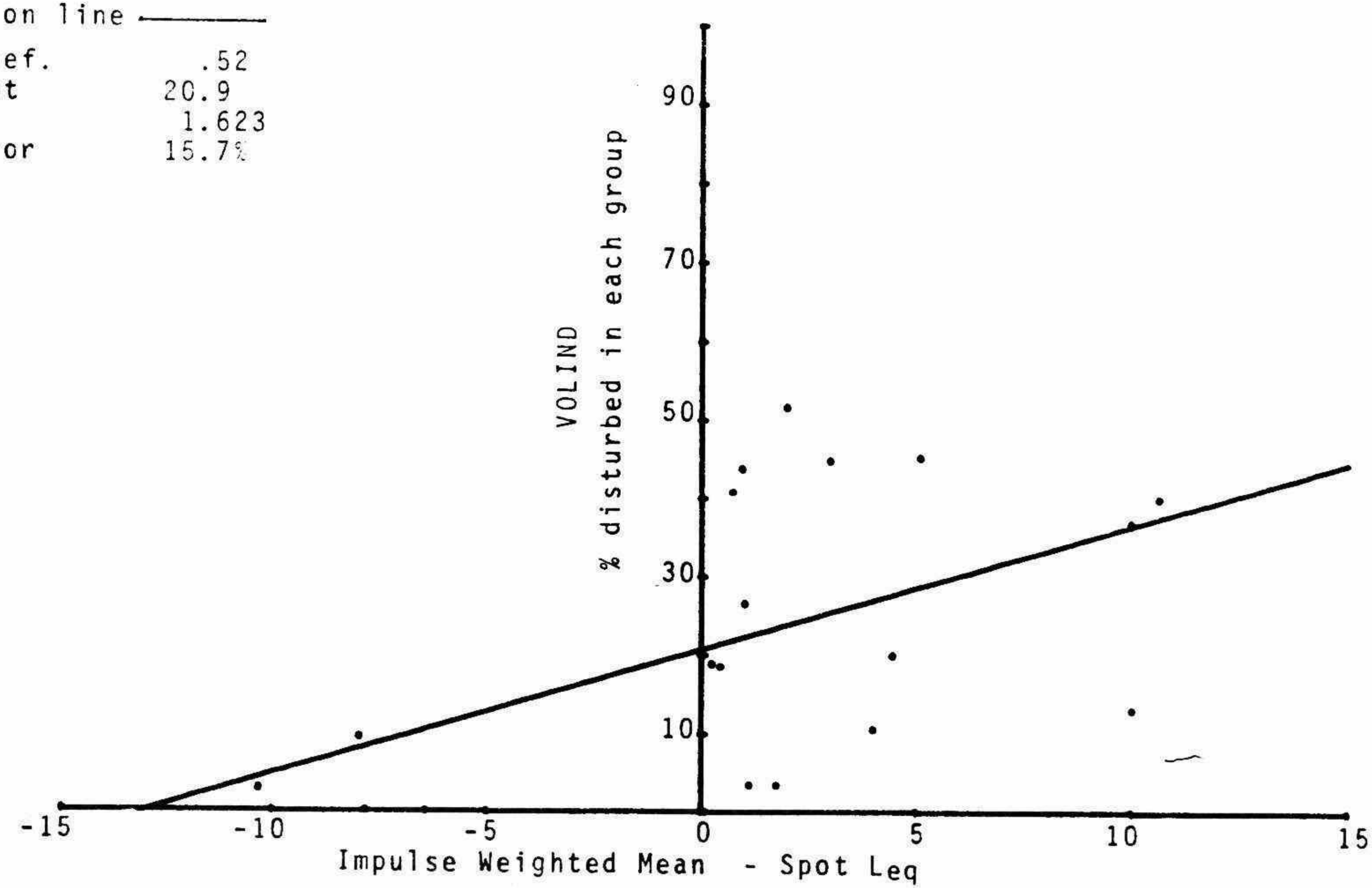



Fig. 65: Regression of NSANY 1 on IMPWMSLQ

Geographically grouped - 19 groups of 32 persons each.

Regression line ——

| | |
|---|---|
| Corr. Coef. | .52 |
| Intercept | 20.9 |
| Slope | 1.623 |
| Std. error | 15.7% |




<u>Fig. 66</u>: Regression of VOLIND on IMPWMSLQ

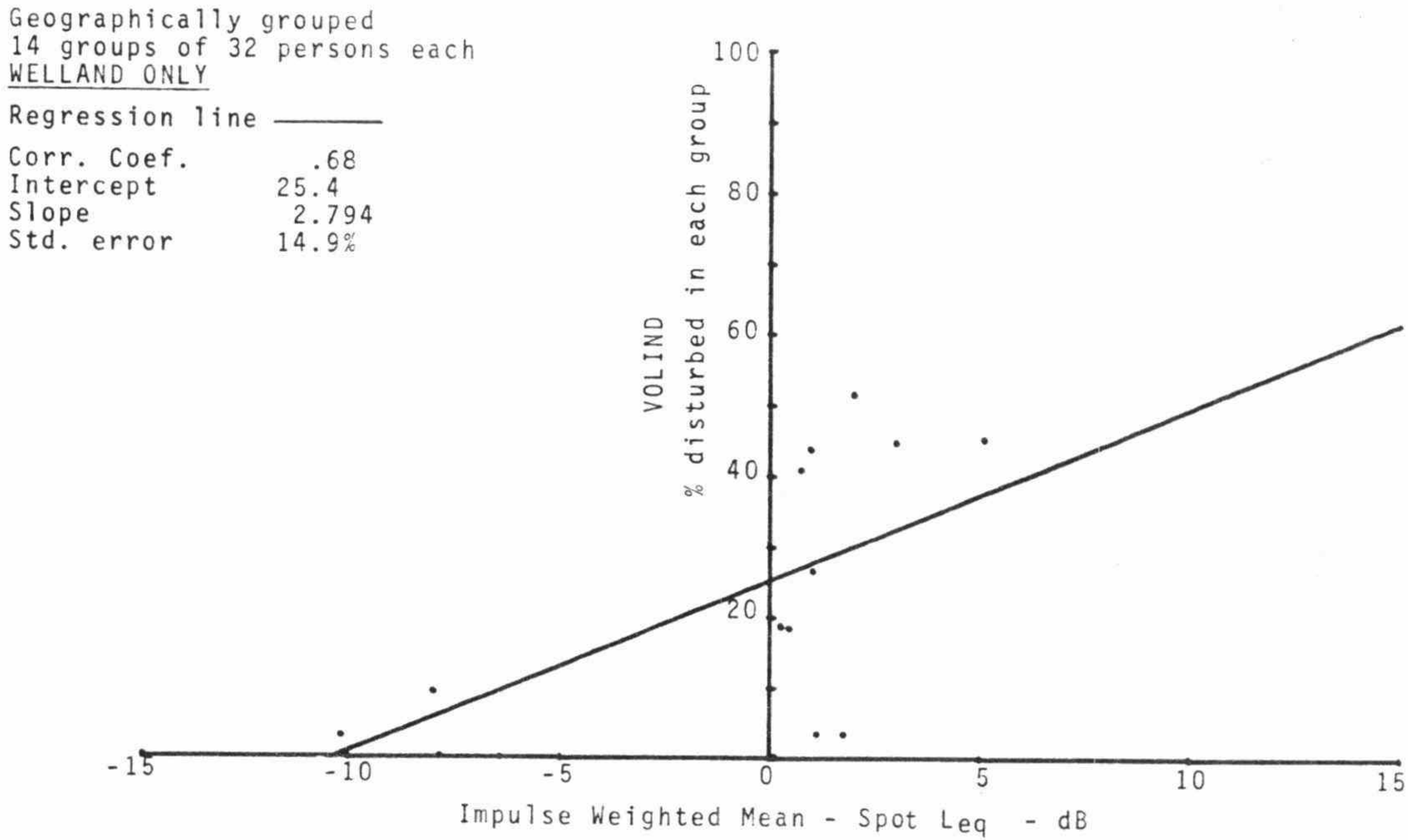



Fig. 67: Regression of VOLIND on IMPWMSLQ

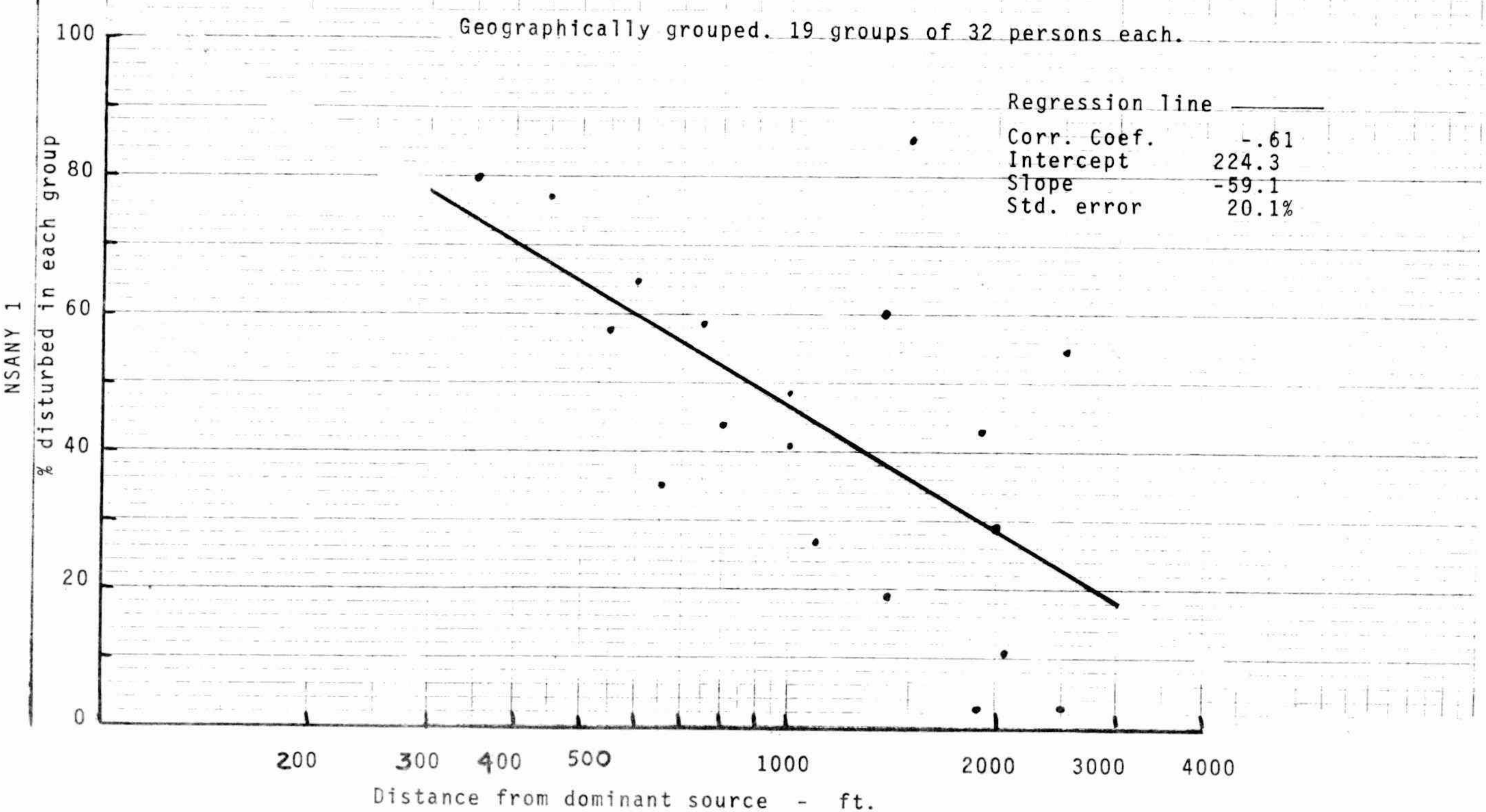



Fig. 68: Regression of NSANY 1 on log (distance)

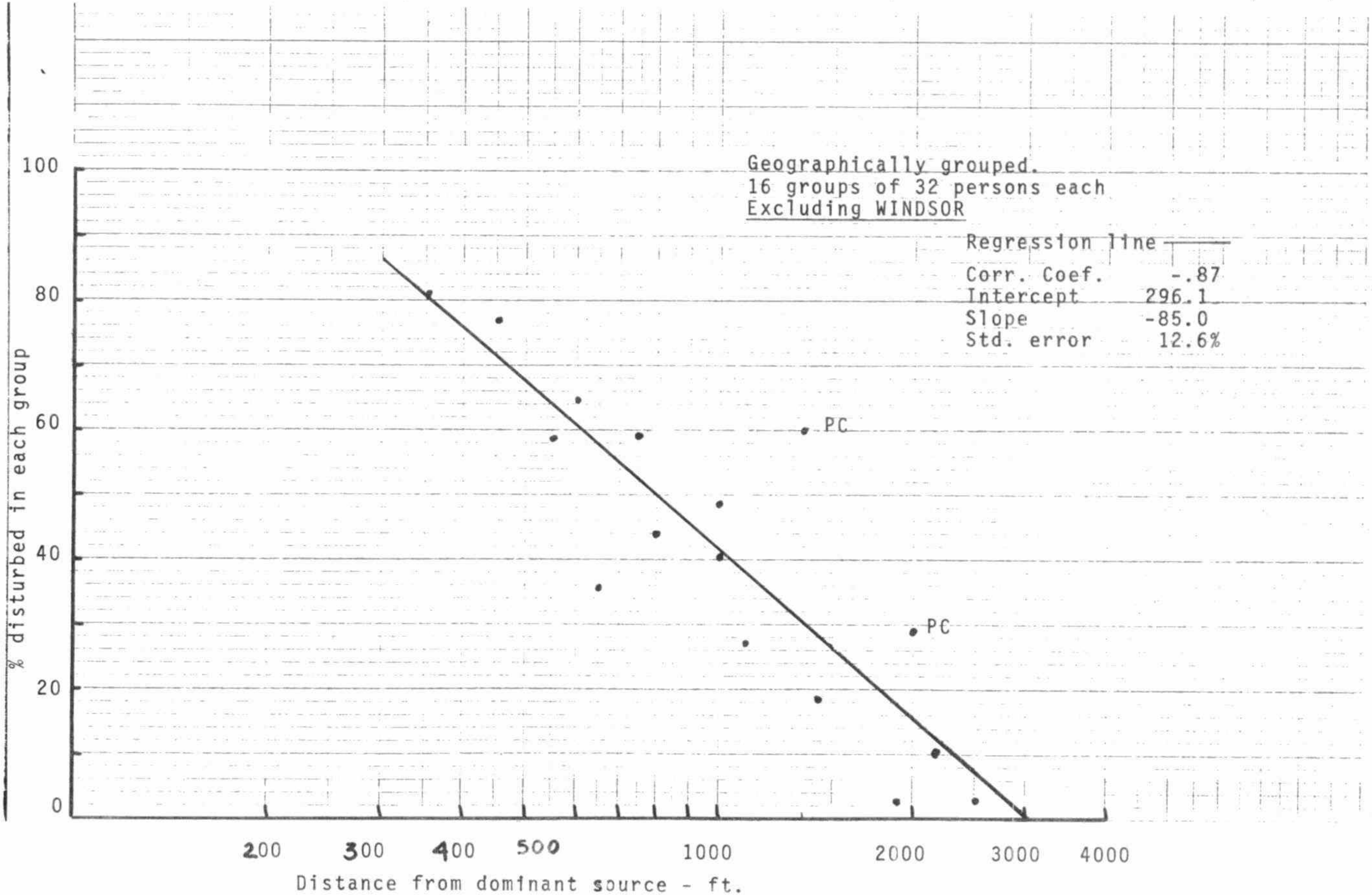



Fig. 69: Regression of NSANY 1 on log (distance)

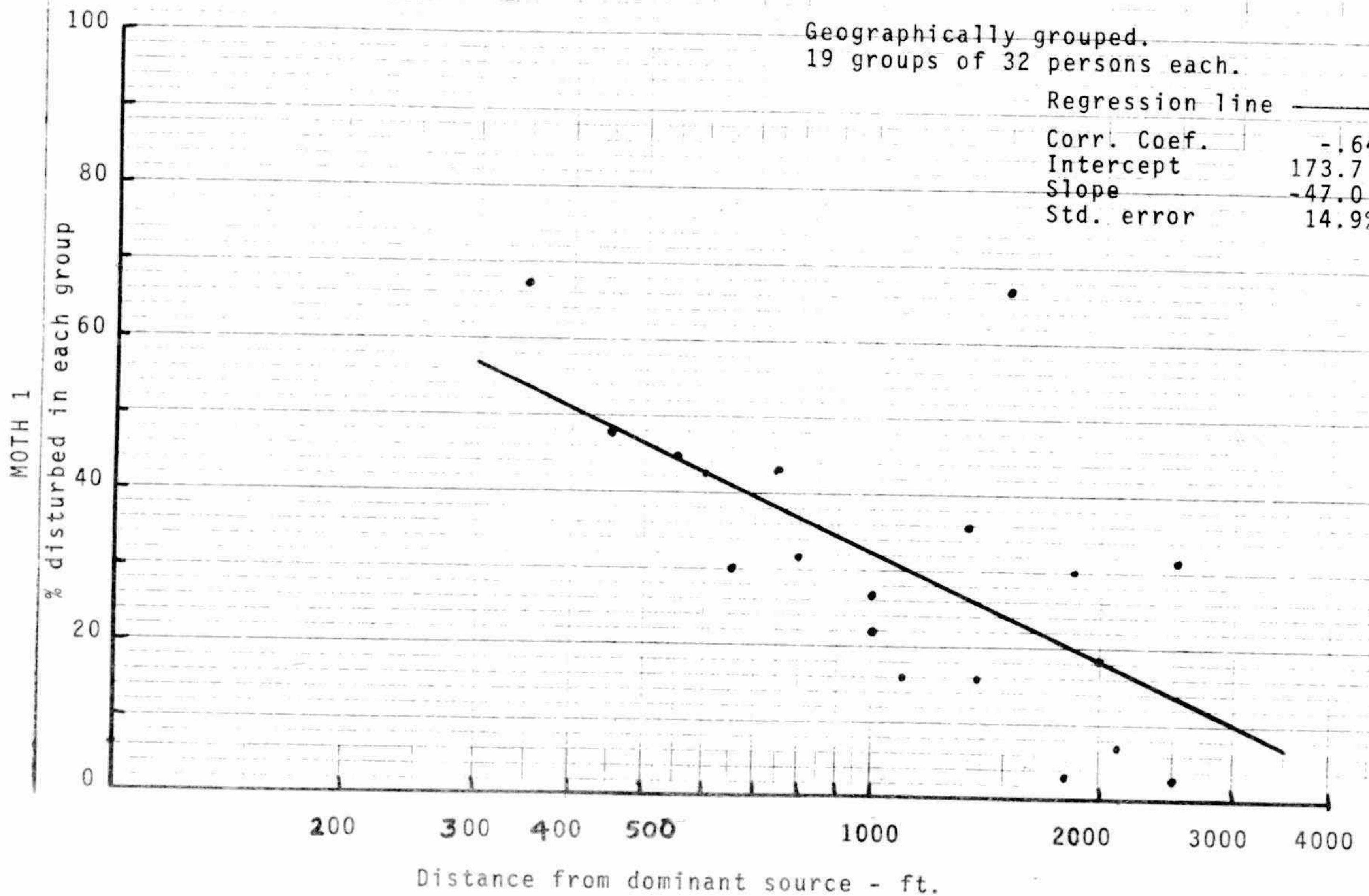



Fig. 70: Regression of MOTH 1 on log (distance)

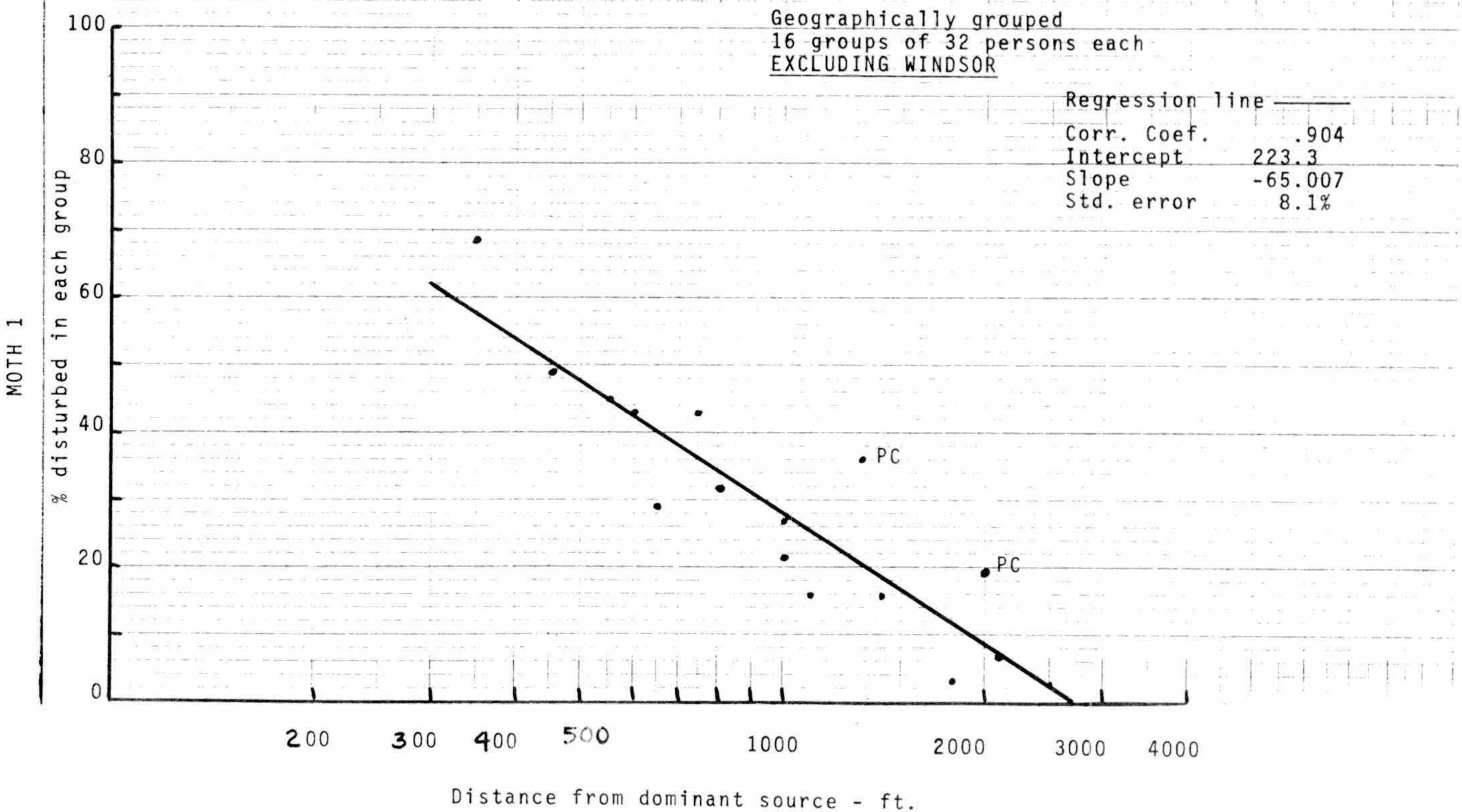



Fig. 71: Regression of MOTH 1 on log (distance)

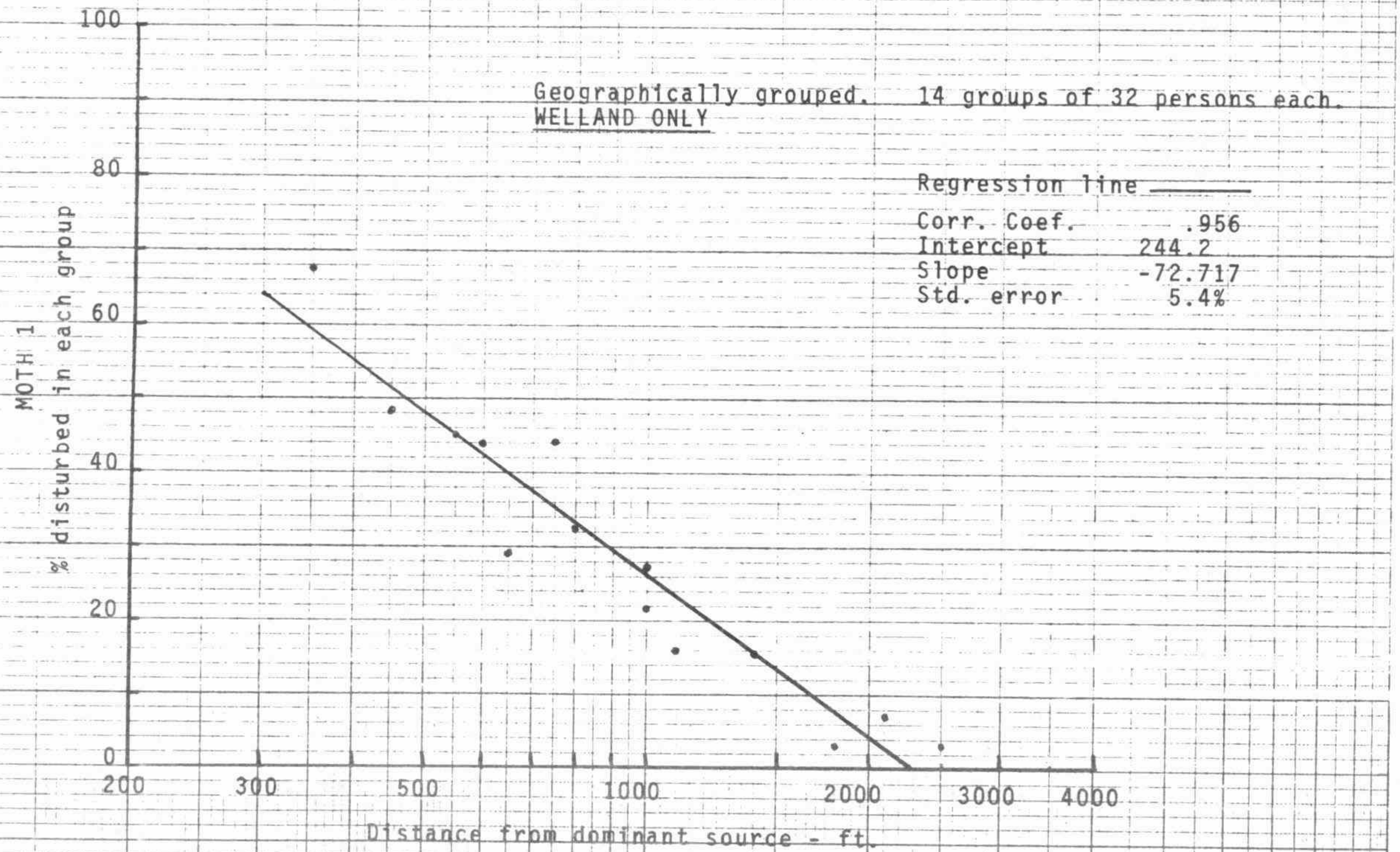



Fig. 72: Regression of MOTH 1 on log distance

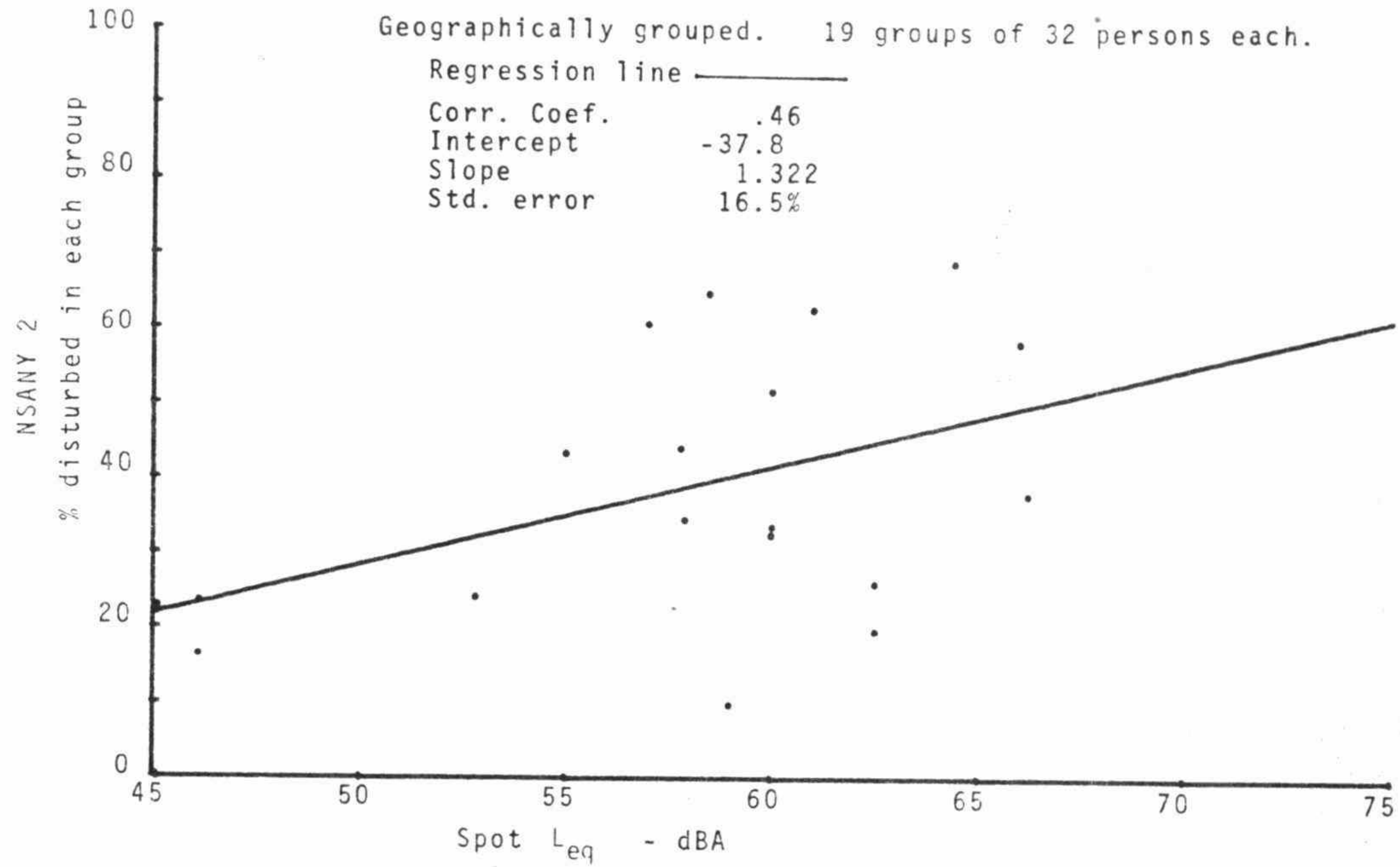



Fig. 73: Regression of NSANY 2 on Spot $L_{eq}$.

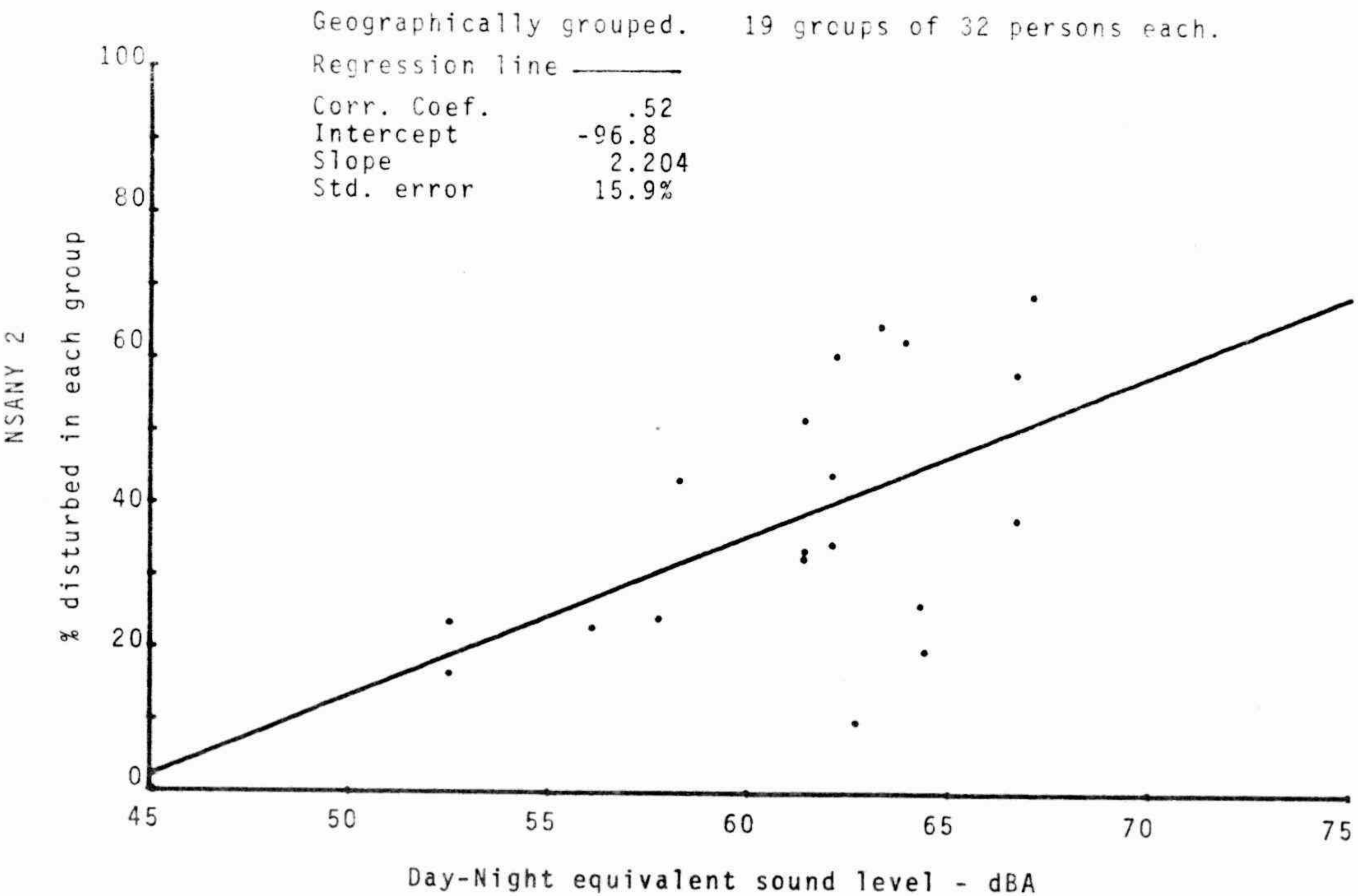



Fig. 74: Regression of NSANY 2 on $L_{DN}$

APPENDIX A

## NEIGHBOURHOOD FACTORS QUESTIONNAIRE

Interviewer: ______________________ ....... ____

Site: ______________________ ....... ____

Address: ______________________ ....... ____

Result of Call: Accept: ______________________ ....... ____

| Date | Time In | Time Out | Not Home | Reason for Refusal | Date & Time of Call Back |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

1. (a) How many years have you lived in this house, (apartment)?........................................ ____

IF LESS THAN 10 YEARS, ASK:

(b) What was your previous address or location?

______________________

2. (a) What three things do you <u>like</u> the most about living in this neighbourhood?

(1) ______________________

(2) ______________________

(3) ______________________

(b) What three things do you <u>dislike</u> the most about living in this neighbourhood?

(1) ______________________

(2) ______________________

(3) ______________________

3. (a) Are you: (1) Close to shopping facilities____, (2)Far from shopping facilities_____,(3)Neither____.................._____

(b) Do you like being (MENTION RESPONSE ABOVE)
(1)Yes_____, (2)_____, (3)Neither_____.................._____

4. (a) Are you:(1)Close to your place of work_____, (2)Far from your place of work_____,(3)Neither_____.............._____

(b) Do you like being (MENTION RESPONSE ABOVE)
(1)Yes_____,(2)No_____(3)Neither_____...................._____

5. Is there:(1) Enough open space in your neighbourhood _____, (2)Not enough open space____,(3)Neither____,.............._____

6. (a) Are there:(1)Enough recreational facilities in your neighbourhood_____,(2)Not enough_____,(3)Neither____......_____

IF (2) ABOVE, ASK:

(b) What type of recreational facilities would you like to have in your neighbourhood?(1)Outdoor sports___, (2)Indoor sports_____,(3)Arts and crafts_____, (4)Swimming pool _____,(5)Playground for children_____,(6)Other________________________________ ......._____

(c) Would you be willing to pay more taxes for additional recreational facilities?
(1)Yes_____,(2)No_____,(3)Neither________________ ......._____

7. Is there:(1)Good public transportation in this area______,(2)Poor public transportation in this area_____(3)Neither_____,........................._____

8. (a) Is it generally (1)Quiet ____, or (2) Noisy in your neighbourhood____,(3)Neither____.........................._____

IF (2) OR (3) ABOVE, ASK:

(b) Does the noise sometimes disturb you?(1)Yes_____,(2)No___ (3)Neither_____ ..................................._____

IF "YES" ABOVE, ASK:

(c) When is it disturbing generally? (1)Daytime_____, (2)Evening_____, (3)Night-time_____ ..................... _____

(d) What type of noise disturbs you in this area? Is it:

MENTION TYPE OF NOISE IN TABLE BELOW

| TYPE | YES | (1) | (2) | (3) |
|---|---|---|---|---|
| (1) People | | | | |
| (2) Traffic | | | | |
| (3) Railroad | | | | |
| (4) Industry | | | | |
| (5) Aircraft | | | | |
| (6) Other | | | | |

(e) Does (MENTION EACH RESPONSE ABOVE) disturb you (1)Slightly (2)Moderately (3)Considerably

MARK APPROPRIATE RESPONSE IN TABLE ABOVE

(f) Do you sometimes have to close windows to keep out the noise? (1)Yes_____, (2)No_____ ......................... _____

9. (a) Is the traffic in your neighbourhood: (1)Light_____, (2)Heavy_____, (3)Neither_____ .......................... _____

NOTE: IF "TRAFFIC NOISE" ALREADY MENTIONED MODIFY, QUESTIONS TO SUIT.

(b) Does the traffic in this neighbourhood sometimes disturb you? (1)Yes____, (2)No____, (3)Neither____, ............... _____

IF "YES" ABOVE, ASK:

(c) What is it about traffic that disturbs you? Is it: (1)Smell or dust______, (2)Safety for children______, (3)Noise_____, (4)Other______________________ ....... _____

IF MORE THAN ONE RESPONSE ABOVE, ASK:

(d) Between (MENTION RESPONSES GIVEN ABOVE), which one disturbs you the most? ______________________ ....... _____

(e) Does (MENTION RESPONSE ABOVE)disturb you (1)Slightly____, (2)Moderately____, (3)Considerably____, ................... _____

10. Are your neighbours: (1)Friendly_____, (2)Unfriendly_____, (3)Neither_____................................................_____

11.(a) Are the city services in this neighbourhood, such as garbage pick-up, etc.,: (1)Good_____, (2)Poor_____, (3)Neither_____................................................_____

IF (2) ABOVE, ASK:

(b) Which of the following city services are poor? (1)Garbage pick-up_____, (2)Street cleaning_____, (3)Water Supply_____, (4)Hydro_____, (5)Snow removal___, (6)Other______________________ ......._____

IF MORE THAN ONE RESPONSE ABOVE, ASK:

(c) Between (MENTION RESPONSES GIVEN ABOVE), which is the worst? ______________________

12.(a) Would you say the air in this area is generally: (1)Clean or fresh_____, (2)Smelly or dusty_____, (3)Neither_____,.............................................._____

IF (2)OR (3) ABOVE, ASK:

(b) Does the smell or dust in air sometimes bother you: (1)Yes____, (2)No____,.............................................._____

IF "YES" ABOVE, ASK:

(c) Does it: (1)Bother you slightly_____, (2)Moderately____, (3)Considerably_____,........................................._____

(d) Would you say the smell,or dust in air is produced by: (1) Traffic_____, (2)Industry_____, (3)Railroad_____, (4)Other______________________ ......._____

13.(a) Would you say this is a: (1)Safe neighbourhood _____, (2)Unsafe____, (3)Neither_____,..................................._____

IF (2)ABOVE ASK:

(b) Do you feel you have adequate police protection: (1)Yes_____, (2)No_____, (3)Neither_____..........................._____

14. What one feature would you most like to have in this neighbourhood?______________________ ......._____

## ACTIVITIES

15 (a) On the average, how much of the daytime (7am-7pm) do you spend at home on weekdays? (1)None(0-1 hr)____, (2)A small portion (1-4 hrs)____, (3)Much(4-8 hrs)____, (4)All of the daytime (8-12 hrs)_____......................_____

IF (3) OR (4)ABOVE:

(b) Are you at home on weekdays because you (1)Work swing shifts____, (2)Are self-employed____, (3)Are retired____ (4)Are a housewife____, (5)Are unemployed_____, (6) Other__________________ ......._____

MENTION FOLLOWING QUESTIONS ON INDOOR ACTIVITIES

16 (a) Which of the following things do you often do when you are indoors at home? Please answer "Yes" or "No". (1)Reading or writing____, (2)Listening to music____, (3)Watching T.V._____, (4)Hobbies _____, (5)Home cleaning_____, (6)Cooking____, (7)Playing indoor sports or games____, (8)Other__________________ ........_____

IF EITHER TRAFFIC NOISE OR ANY OTHER TYPE OF NOISE CHECKED EARLIER (QUESTIONS 8(d) or 9(c)), ASK FOLLOWING QUESTION. IF NOT, SKIP TO QUESTION 2(c).

(b) Does (MENTION RESPONSE FROM 8(d) or 9(c)) disturb you when you are (MENTION TWO RESPONSES FROM 2(a) ABOVE) at home indoors? (1)Yes____, (2)No____, (3)Neither_____,........................................_____

IF ABOVE QUESTION ASKED, SKIP TO 3(a), OTHERWISE ASK QUESTION BELOW

(c) Do any of the following disturb you when you are (MENTION TWO RESPONSES FROM 16(a) ABOVE) at home indoors? Please answer "Yes" or "No". (1)Outdoor power tools____, (2)Neighbours____, (3)Children____, (4)Noise outside____, (5)Telephone____, (6)Household appliances____, (7)Other____ _____

IF (4) ABOVE, ASK:

(d) What type of noise disturbs you? Is it:(1)Traffic___, (2)People____, (3)Railroad____, (4)Industry____, (5)Aircraft____, (6)Other__________________ ......._____

MENTION FOLLOWING QUESTIONS ON OUTDOOR ACTIVITIES

17 (a) Which of the following things do you often do when you are outdoors at home? Please answer "Yes" or "No"
(1)Reading____,(2)Relaxing____,(3)Talking with family or friends_____,(4)Barbecuing___, (5)Gardening____,
(6)Mechanical or carpentry work,_____,(7)Playing sports or games_____,(8)Eating____,(9)Other__________ ......._____

(b) Do any of the following disturb you when you are (MENTION TWO RESPONSES GIVEN ABOVE) at home outdoors?

IF "DISTURBED INDOORS", OMIT DISTURBING SOURCE FROM LIST BELOW.

(1)Outdoor power tools____,(2)Neighbours____,
(3)Children____,(4)Noise Outside_____,(5)Smell or dust in air____,(6)Other______________________ ......._____

| | |
|---|---|
| (c) IF (4) ABOVE, ASK: What type of noise disturbs you? Is it: (1)Traffic____, (2)People____,(3)Rail-road____,(4)Industry____. (5)Aircraft____, (6)Other__________ | (e) IF (5) ABOVE, ASK: What produces the smell or dust? Is it: (1)Traffic____,(2)Rail-road_____,(3)Industry____, (4)Other__________ |
| (d) IF MORE THAN ONE MENTIONED, ASK: Between (MENTION RESPONSES ABOVE) which disturbs you the most? | |

(c) ____
(d) ____
(e) ____

18 (a) Would you consider yourself to be a: (1)Light sleeper___,
(2)Moderate sleeper____,(3)Sound sleeper____,........... ____

(b) Do you sometimes have trouble falling asleep?
(1)Yes____,(2)No____,.................................... ____

IF "YES" ABOVE, ASK:

(c) Do any of the following keep you from falling asleep?
(1)Outdoor power tools____,(2)Neighbours____,
(3)Children____,(4)Noise outside____,(5)Telephone____,
(6)Personal matters ____,(7)Other__________________ ____

IF (4) ABOVE ASK:

(d) What type of noise disturbs your sleep? Is it:
(1)Traffic____,(2)People____,(3)Railroad____,(4)Industry____,
(5)Aircraft____,(6)Other________________ ____

(e) Do you sometimes have to close the windows when trying to sleep? (1)Often____,(2)Sometimes____,(3)Never____ ____

PERSONAL DATA

MENTION FOLLOWING QUESTIONS PERSONAL, ANSWERS VOLUNTARY, RE-EMPHASI CONFIDENTIALITY.

1. Sex: (1)Male____,(2)Female____,.......................... ____

2. How many persons are there in this household?............ ____

3. Would you tell me your age please?...................... ____

NOTE IF EXACT AGE IS MENTIONED IMMEDIATELY. IF NOT ASK:
Is it: (1)25 or under____,(2)Between 26 and 35____,
(3)36 and 45____,(4)46 and 60____,(5)Over 61____, ....... ____

4. Have you attended: (1)Elementary school____,
(2)High school___,(3)Community College____,(4)Occupational Training Course____,(5)University____,............ ____

5. What is your main occupation? (e.g., housewife, engineer, plumber, etc)________________ ____

IF OTHER THAN HOUSEWIFE, ASK:

6. (a) Are you working now? (1)Yes____,(2)No____,.............. ____

IF ANSWER ABOVE IS "YES", ASK:

(b) Do you work in a(n): (1)Office____,(2)Store____,
(3)Restaurant____,(4)Plant or factory____,
(5)Outdoor____,(6)Other________________ ____

7. Was the total income before taxes of this household in the past year:
(1)Under $10,000____,(2)Between $10,000 and $20,000____,
(3)Between $20,000 and $30,000____,(4)Over $30,000____.
(5)Rather not say____,................................ ____

8. (a) Do you rent or own this house (apartment or flat)?
(1)Own____,(2)Rent____,............................ ____

IF "OWN", ASK:

(b) Are the property taxes in this neighbourhood:
(1)Low____,(2)High____,(3)Neither____,............ ____

IF "RENT", ASK:

(c) Are the rents in this neighbourhood:
(1)Low____,(2)High____,(3)Neither____.............. ____

OBSERVATIONAL DATA TO BE NOTED AFTER LEAVING HOUSEHOLD

1. Audible outside noise during interview (if any):
Rate on the following scale of loudness: (1)Barely Audible,(2)Clearly Audible,(3)Interferes with speech

| TYPE OF NOISE | LOUDNESS | CONTINUOUS | INTERMITTENT |
|---|---|---|---|
| ____ | ____ | ____ | ____ |
| ____ | ____ | ____ | ____ |
| ____ | ____ | ____ | ____ |

2. Type of dwelling: (1)Apartment____,(2)Flat____,
(3)Row____,(4)Semi-detached____,(5)Detached____,....... ____

3. Number of floors:.................................... ____

4. If apartment or flat, which floor?.................. ____

5. If apartment or flat, front or back of building?
7 (1)Front____,(2)Back____............................. ____

6. Building Material: (1)Brick____,(2)Frame____,
(3)Other__________.................................... ____

7. Windows: (1)Single pane____,(2)Two panes (storm or double-glazing)____,(3)Not observed____,............ ____
and (1)Will open____,(2)Won't open____,
(3)Not observed____,.......................... ____

8. Air conditioning: (1)None____,(2)Window____,
(3)Central____,(4)Not observed____................. ____

9. Location of interview (1)Indoor____,(2)Outdoor____, ____

10. Command of English.

________________________________________ ____

# APPENDIX B

## Schedule I

### Index of Publications



SOURCE: Model Municipal Noise Control By-Law,Final Report,August 1978.

Publication NPC-101

Technical Definitions

1. Technical Terminology and Standards

The following terminology and standards shall be used for the purposes of any Noise Control By-Law enacted pursuant to The Environmental Protection Act and all Publications of the Noise Pollution Control Section of the Pollution Control Branch of the Ministry of the Environment. The definition of any technical word used in such By-Law or this or any such Publication and not herein defined shall be the definition appearing in the applicable Publication of the Canadian Standards Association (CSA), the American National Standards Institute (ANSI), the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), the Society of Automotive Engineers (SAE), or the Machinery and Equipment Manufacturers Association of Canada (MEMAC):

(1) Acoustic Calibrator

An "Acoustic Calibrator" is an electro-mechanical or mechanical device intended for the calibration of sound level meters and meeting the specifications of Publication NPC-102 - Instrumentation, for Acoustic Calibrators.

(2) A-Weighting

"A-weighting" is the frequency weighting characteristic as specified in IEC 123 or IEC 179 and intended to approximate the relative sensitivity of the normal human ear to different frequencies (pitches) of sound.

(3) A-weighted Sound Pressure Level

The "A-weighted sound pressure level" is the sound pressure level modified by application of the A-weighting. It is measured in decibels, A-weighted, and denoted dBA.

(4) Beating

"Beating" is the characteristic of a sound which has an audible cyclically varying sound level, caused by the interaction of two sounds of almost the same frequency.

(5) Buzzing Sounds

A "buzzing sound" is a sound which is characterized by the presence of a large number of related discrete harmonics in its frequency spectrum. These harmonics together with the fundamental frequency produce a sound which subjectively is termed a "buzz". Examples are sounds from a buzzer or a chain saw.

(6) Decibel

The "decibel" is a dimensionless measure of sound level or sound pressure level; see sound pressure level.

(7) Effective Sound Pressure

The "effective sound pressure" at a point is the root-mean square value of the instantaneous sound pressure, over a time interval, at the point under consideration as detected with a sound level meter meeting the requirements of Publication NPC-102 - Instrumentation.

(8) Equivalent Sound Level

The "equivalent sound level" sometimes denoted $L_{eq}$, is the value of the constant sound level which would result in exposure to the same total A-weighted energy as would the specified time-varying sound, if the constant sound level persisted over an equal time interval. It is measured in dBA.

The mathematical definition of equivalent sound level ($L_{eq}$) for an interval defined as occupying the period between two points in time $t_1$ and $t_2$ is:

$$L_{eq} = 10 \log_{10} \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p^2(t)}{p_r^2} \, dt$$

where p(t) is the time varying A-weighted sound pressure and $p_r$ is the reference pressure of 20 μPa.

(9) Fast Response

"Fast response" is a dynamic characteristic setting of a sound level meter meeting the applicable specifications of Publication NPC-102 - Instrumentation.

(10) Frequency

The "frequency" of a periodic quantity is the number of times that the quantity repeats itself in a unit interval of time. The unit of measurement is hertz (Hz) which is the same as cycles per second.

(11) General Purpose Sound Level Meter

A "General Purpose Sound Level Meter" is a sound level meter which meets the specifications of Publication NPC-102 - Instrumentation, for General Purpose Sound Level Meters.

(12) Impulse Response

"Impulse response" is a dynamic characteristic setting of a sound level meter meeting the specifications of Publication NPC-102 - Instrumentation, for Impulse Sound Level Meters.

(13) Impulsive Sound

An "impulsive sound" is a single pressure pulse or a single burst of pressure pulses, as defined by IEC 179A, First supplement to IEC 179, Sections 3.1 and 3.2.

(14) Impulse Sound Level

The "impulse sound level" is the sound level of an impulsive sound as measured with an Impulse Sound Level Meter set to impulse response. It is measured in A-weighted decibels, denoted dBAI.

(15) Impulse Sound Level Meter

An "Impulse Sound Level Meter" is a sound level meter which meets the specifications of Publication NPC-102 - Instrumentation, for Impulse Sound Level Meters.

(16) Integrating Sound Level Meter

An "Integrating Sound Level Meter" is a sound level meter which is capable of being used to derive the equivalent sound level ($L_{eq}$) and which meets the specifications of Publication NPC-102 - Instrumentation, for Type B Integrating Sound Level Meters.

(17) Logarithmic Mean Impulse Sound Level

The "Logarithmic Mean Impulse Sound Level", sometimes denoted $L_{LM}$, of N impulsive sounds, is ten times the logarithm to the base 10 of the arithmetic mean of ten to the power of one tenth the impulse sound level of each impulsive sound.

Algebraically, it can be written as:

$$L_{LM} = 10 \log_{10} \left[ \frac{1}{N} \left( 10^{dBAI_1/10} + 10^{dBAI_2/10} \ldots + 10^{dBAI_N/10} \right) \right]$$

where, $dBAI_1$, $dBAI_2$, ....$dBAI_N$, are the N impulse sound levels.

(18) Overpressure

The "overpressure" at a point due to an acoustic disturbance is the instantaneous difference at that point between the peak pressure during the disturbance and the ambient atmospheric pressure. The unit of measurement is the pascal. One pascal, abbreviated Pa, is the same as one newton per square metre, abbreviated $N/m^2$.

(19) Overpressure Level

The "overpressure level" is twenty times the logarithm to the base 10 of the ratio of the peak pressure to the reference pressure of 20 $\mu$Pa.

(20) Peak Particle Velocity

The "peak particle velocity" is the maximum instantaneous velocity experienced by the particles of a medium when set into transient vibratory motion. This can be derived as the magnitude of the vector sum of three orthogonal components and is measured in cm/s.

(21) Peak Pressure Level Detector

A "Peak Pressure Level Detector" is a device capable of measuring peak pressure or pressure level perturbations in air and which meets the specifications of Publication NPC-102 - Instrumentation, for Peak Pressure Level Detectors.

(22) Percentile Sound Level

The "x percentile sound level", designated $L_x$, is the sound level exceeded x percent of a specified time period. It is measured in dBA.

(23) Quasi-Steady Impulsive Sound

"Quasi-Steady Impulsive Sound" is a sequence of impulsive sounds emitted from the same source, having a time interval of less than 0.5 s between successive impulsive sounds.

(24) Slow Response

"Slow response" is a dynamic characteristic setting of a sound level meter meeting the applicable specifications of Publication NPC-102 - Instrumentation.

(25) Sound

"Sound" is an oscillation in pressure, stress, particle displacement or particle velocity, in a medium with internal forces (e.g. elastic, viscous), or the superposition of such propagated oscillations, which may cause an auditory sensation.

(26) Sound Level

"Sound level" is the A-weighted sound pressure level.

(27) Sound Level Meter

A "sound level meter" is an instrument which is sensitive to and calibrated for the measurement of sound.

(28) Sound Pressure

The "sound pressure" is the instantaneous difference between the actual pressure and the average or barometric pressure at a given location. The unit of measurement is the micropascal ( $\mu$Pa) which is the same as a micronewton per square metre ( $\mu N/m^2$).

(29) Sound Pressure Level

The "sound pressure level" is twenty times the logarithm to the base 10 of the ratio of the effective pressure (p) of a sound to the reference pressure ($p_r$) of 20 $\mu$Pa. Thus the sound pressure level in dB = $20 \log_{10} \frac{p}{p_r}$.

(30) Tonality

A "tone" or a "tonal sound" is any sound which can be distinctly identified through the sensation of pitch.

(31) Vibration

"Vibration" is a temporal and spatial oscillation of displacement, velocity or acceleration in a solid medium.

(32) Vibration Velocity Detector

A "Vibration Velocity Detector" is a device which is capable of measuring vibration velocity and which meets the specifications of Publication NPC-102 - Instrumentation, for Vibration Velocity Detectors.

Publication NPC-102

Instrumentation

1. Scope

This Publication sets out minimum specifications for equipment used for the measurement of sound and vibration. For most of the specifications the International Electrotechnical Commission (IEC) recommended standards 123 (First edition 1961), 179 (Second edition 1973) and 179A (First supplement to IEC 179, published 1973) have been adopted. In some cases, these standards are amended or augmented for greater precision.

TABLE 102-1

| NPC-102 Section | Type of Instrument | Application |
|---|---|---|
| 3 | General Purpose Sound Level Meter | Non-impulsive sounds |
| 4 | Impulse Sound Level Meter | Impulsive sounds |
| 5 | Peak Pressure Level Detector | Peak pressure perturbations |
| 6 | Type B Integrating Sound Level Meter | Varying sounds of low crest factor |
| 7 | Type A Integrating Sound Level Meter | Varying sounds of high crest factor |
| 8 | Vibration Velocity Detector | Peak vibration velocity in solids |
| 9 | Acoustic Calibrator | Calibration of sound level meters |

2. Technical Definitions

The technical terms used in this Publication are defined in the specifications themselves or in Publication NPC-101 - Technical Definitions.

3. General Purpose Sound Level Meter

(1) Purpose

A General Purpose Sound Level Meter is a sound level meter which is intended to be used for the measurement of non-impulsive sounds, without significant A-weighted acoustic energy above 2000 Hz.

(2) Specifications

A sound level meter which meets the following specifications is a General Purpose Sound Level Meter:

(a) the sound level meter, including a microphone equipped with a windscreen shall meet the specifications of IEC 123, except that, in addition to meeting the specifications of subclause 5.2 thereof, the microphone of the sound level meter shall also meet the specifications of subclause 5.2 amended by the substitution therein of an angle of incidence of $\pm 30^{o}$ instead of $\pm 90^{o}$, as it therein appears, and by the substitution of Table 102-2 hereof instead of Table 1, as it therein appears;

(b) the sound level meter shall incorporate A-weighting, which is specified in IEC 123 as optional;

(c) the sound level meter shall have a minimum usable range of sensitivity of from 40 dBA to 100 dBA and it shall read to an accuracy of $\pm 1.0$ dB over that range;

(d) a windscreen shall be installed on the microphone and shall not affect by more than 1 dB the tolerance prescribed in clauses (a) and (c);

(e) the sound level meter, including a microphone equipped with a windscreen, shall, when operated in the presence of wind, indicate a wind-induced sound level not in excess of the relevant value listed in Table 102-3.

4. Impulse Sound Level Meter

(1) Purpose

An Impulse Sound Level Meter is a sound level meter which is intended to be used for the measurement of any sounds, including sounds for which a General Purpose Sound Level Meter may be used.

(2) Specifications

A sound level meter which meets the following specifications is an Impulse Sound Level Meter:

(a) the sound level meter, including a microphone equipped with a windscreen, shall meet the specifications of a General Purpose Sound Level Meter;

(b) the sound level meter, including a microphone equipped with a windscreen, shall meet the specifications of IEC 179 and IEC 179A, supplement to IEC 179, including the optional characteristics mentioned in subclause 4.5 of IEC 179A;

(c) the sound level meter shall incorporate A-weighting as specified in IEC 179.

5. Peak Pressure Level Detector

(1) Purpose

A Peak Pressure Level Detector is a sound level meter which is intended to be used for the measurement of peak pressure perturbations in air. The value indicated by this device is not an average of the pressure level perturbations.

(2) Specifications

A sound level meter which meets the following specifications is a Peak Pressure Level Detector (the features of this device are incorporated in an Impulse Sound Level Meter as specified in section 4 above):

(a) the microphone of the sound level meter, when equipped with a windscreen, shall perform within a tolerance of ±1 dB throughout the frequency range of from 5 Hz to 31.5 Hz in the circumstances and conditions for use set out in Table 1 of IEC 179;

(b) the sound level meter without the microphone shall be capable of providing linear response as specified in subclause 4.5 of IEC 179, within a tolerance of ±1 dB throughout the frequency range of from 5 Hz to 15 kHz;

(c) the sound level meter shall incorporate the optional characteristics specified in subclause 4.5 of IEC 179A;

(d) the sound level meter shall meet the specifications set out in IEC 179 clause 3, subclauses 4.1, 4.2, 4.4, 4.5, 4.7, 4.8, clause 5, subclauses 6.2, 6.3, 6.4, 6.5, 6.8, 6.9, 7.1 through 7.9, 7.11, 8.1, 8.2, 8.3, 8.6 through 8.9, and the appropriate specifications of clause 10.

6. Type B Integrating Sound Level Meter

(1) Purpose

(a) An Integrating Sound Level Meter is a sound level meter which is intended to be used for the measurement of sound over a period of time, such that the equivalent sound level ($L_{eq}$) of the sound may be obtained.

(b) The Type B Integrating Sound Level Meter is specified with sufficient dynamic range and measurement precision to measure equivalent sound levels of general sounds that exceed limitations set out in this by-law.

(c) Either a Type A or Type B Integrating Sound Level Meter may be used for most such applications, but a Type A Integrating Sound Level Meter must be used when the sound under study

is Quasi-Steady Impulsive Sound (see NPC-103 - Procedures, sections 3 and 4) or when the operational dynamic range greatly exceeds 40 dB.

(2) General Description

The tolerances specified for the microphone, weighting and amplifier of a Type B Integrating Sound Level Meter are the same as those specified for a General Purpose Sound Level Meter in section 3 of this Publication. The computational portions of the instrument must operate within a net accuracy of ±1 dB for time periods of 20 minutes to one hour over a dynamic range of at least 40 dB with test signals having a crest factor (as defined in IEC 179A) up to 3. An operator-activated switch is included to inhibit the integration function alone and, if the system includes an elapsed-time clock, to inhibit both the integration and time summation functions.

(3) Specifications

A sound level meter which meets the following specifications is a Type B Integrating Sound Level Meter:

(a) the instrument will generally be a combination of microphone, amplifier, A-weighting network, computation circuit to obtain the integral of the mean square A-weighted pressure, display and a means of inhibiting the integration, but may vary from the above provided that it performs the same functions within the tolerances set out below;

(b) the instrument may include computational circuitry to calculate and display the equivalent sound level directly;

(c) the microphone of the instrument shall meet the specifications of clause 5 of IEC 123, except that, in addition to meeting the specifications of subclause 5.2 thereof, the microphone shall also meet the specifications of subclause 5.2 amended by the substitution therein of an angle of incidence of $\pm 30^{0}$ instead of $\pm 90^{0}$, as it therein appears, and by the substitution of Table 102-2 hereof instead of Table 1, as it therein appears;

(d) a windscreen shall be installed on the microphone during operation and shall not affect by more than 1 dB the tolerance prescribed in clause (c);

(e) the sound level meter, including a microphone equipped with a windscreen, shall, when operated in the presence of wind, indicate a wind-induced sound level not in excess of the relevant value listed in Table 102-3.

(f) the A-weighting network shall meet the specifications of Table II and Figure I of IEC 123;

(g) the amplifier shall meet the specifications of subclauses 7.2, 7.3 and 7.11 of IEC 123;

(h) for each sensitivity setting of the instrument the amplifier shall have a power handling capacity at least 10 dB greater than the maximum sound level specified for that sensitivity setting;

(i) if the computation circuit is of the sampling (digital) type, when operating in conjunction with the microphone, windscreen, A-weighting network and amplifier, it shall generate a signal proportional to the mean square A-weighted pressure with a 1 $\pm$0.25 s exponential averaging time constant;

(j) the computation circuit shall integrate the mean square A-weighted pressure and shall be capable of doing so on each sensitivity setting for a minimum of 6 minutes at the maximum sound level specified for that sensitivity setting;

(k) if the computation circuit is not capable of meeting the specification of clause (j) with the reference therein to "6 minutes" changed to "60 minutes", then the device shall be provided with a means to indicate to the operator when the integration capability has been exceeded;

(l) if the computational circuit is of the sampling (digital) type, sampling shall take place at least twice per second;

(m) the computation circuit shall operate over the usable dynamic range of the instrument with a linearity of $\pm$1 dB for any sound with a ratio of peak pressure to root mean square pressure up to 3 (crest factor up to 3);

(n) an operator-activated switch shall be provided to inhibit integration or, if the instrument has an internal elapsed time clock, to inhibit both integration and accumulation of time;

(o) the combination of windscreen, microphone, A-weighting network, amplifier and computation circuit shall have a usable dynamic range extending at least from 50 dBA to 90 dBA and the manufacturer shall specify the usable dynamic range;

(p) the instrument may be provided with more than one sensitivity setting and the manufacturer shall specify the minimum and maximum input sound level for each sensitivity setting;

(q) if the maximum sound level specified for any sensitivity setting is less than 100 dBA, the system shall include a means of indicating to the operator that the maximum input sound level for that sensitivity setting has been exceeded and such indication shall be maintained until cancelled by the operator;

(r) the display shall indicate either,

  (i) an output proportional to the integrated mean square A-weighted pressure, or

  (ii) the integrated mean square A-weighted pressure divided by the duration of the period of time for which the equivalent sound level is to be determined, or

(iii) the equivalent sound level for the period of time for which the equivalent sound level is to be determined;

(s) it shall be possible to read from the display or to calculate from the reading of the display, the equivalent sound level to a resolution of ±1 dB over the usable dynamic range of the instrument for integration times from 20 minutes to 60 minutes;

(t) if the indication of the display is as described in subclause (ii) or (iii) of clause (r), the instrument shall include an elapsed-time clock;

(u) the complete instrument shall follow the recommendations and meet the specifications of subclauses 7.4, 7.5, 7.6, 7.7, 7.8 and 7.9 of IEC 123; and

(v) the instrument shall include a means of determining whether the battery of the instrument if any, has sufficient life to permit proper operation for a period of at least one hour.

7. Type A Integrating Sound Level Meter

(1) Purpose

(a) An Integrating Sound Level Meter is a sound level meter which is intended to be used for the measurement of sound over a period of time, such that the equivalent sound level ($L_{eq}$) of the sound may be obtained.

(b) The Type B Integrating Sound Level Meter is specified with sufficient dynamic range and measurement precision to measure equivalent sound levels of general sounds that exceed limitations set out in this by-law.

(c) Either a Type A or a Type B Integrating Sound Level Meter may be used for most such applications, but a Type A Integrating Sound Level Meter must be used when the sound under study is Quasi-Steady Impulsive Sound (see NPC-103 - Procedures, Sections 3 and 4) or when the operational dynamic range greatly exceeds 40 dB.

(2) General Description

The tolerances specified for the microphone, weighting and amplifier of a Type A Integrating Sound Level Meter are the same as those specified for a General Purpose Sound Level Meter in section 3 of this Publication. The computational portions of the instrument must operate within a net accuracy of ±1 dB for time periods of 20 minutes to one hour over a dynamic range of at least 80 dB with test signals having a crest factor (as defined in IEC 179A) up to 5. An operator activated switch is included to inhibit both the integration and time summation functions.

(3) Specifications

A sound level meter which meets the following specifications is a Type A Integrating Sound Level Meter:

(a) the sound level meter shall meet the specifications of a Type B Integrating Sound Level Meter;

(b) the instrument shall be provided with an internal elapsed-time clock;

(c) for each sensitivity setting of the instrument, the amplifer shall have a power handling capacity at least 14 dB greater than the maximum sound level specified for that sensitivity setting;

(d) the computation circuit shall operate over the usable dynamic range of the instrument with a linearity of ±1 dB for any sound with a ratio of peak pressure to root mean square pressure up to 5 (Crest Factor up to 5); and

(e) the combination of windscreen, microphone, A-weighting network, amplifier and computation circuit shall have a usable dynamic range extending at least from 40 dBA to 120 dBA.

8. Vibration Velocity Detector

(1) Purpose

A Vibration Velocity Detector is a device intended to be used for the measurement of the peak particle velocity of a solid surface.

(2) Specifications

A device which meets the following specifications is a Vibration Velocity Detector:

(a) the device shall include either a transducer which responds to the total vibration vector or three transducers which have their axes of maximum sensitivity mutually orthogonal $\pm 1^{o}$;

(b) where three transducers are used to measure three mutually orthogonal components of vibration, the response of any one of the transducers to vibration in the plane normal to its axis of maximum sensitivity shall be less than 10% of its response to the same vibration along its axis of maximum sensitivity;

(c) the output of the device shall be proportional to the velocity of the surface on which the transducer is, or the transducers are, mounted and the output of the device shall be in such form that the device indicates, or can be used to calculate, the peak particle velocity in the frequency range of from 5 Hz to 500 Hz over a range of peak particle velocity of from 0.25 cm/s to 10 cm/s with a tolerance of ±10%; and

(d) it shall be possible to field-calibrate the device with an accuracy of ±5% using either a reference electrical signal in series with the equivalent transducer impedance or a reference vibration source.

9. Acoustic Calibrator

(1) Purpose

An Acoustic Calibrator is an electro-mechanical or mechanical device which produces sound of a known frequency and which, when coupled to a sound level meter, produces a predictable response in the sound level meter if the sound level meter is operating properly at the calibration frequency.

(2) Specifications

A device, capable of producing sound, which meets the following specifications is an Acoustic Calibrator:

(a) the device shall be capable of being physically attached to a sound level meter in such a way that the device and the sound level meter are "acoustically coupled", that is, sound from the device is transmitted through the air by way of a chamber formed by the attachment of the device to the microphone of the sound level meter;

(b) the device shall produce sound of a stated frequency, within a frequency tolerance of ±5%;

(c) the manufacturer of the device shall provide with the device, any data required in order to determine the sound level reading which should be indicated on the sound level meter when calibrated for those microphone and sound level meter types with which the manufacturer recommends the device be used. Where additional accessories must be used to provide this sound level reading, the manufacturer shall state that they must be used;

(d) the maximum tolerance in the sound pressure level generated by the device when coupled to the microphone shall apply over an atmospheric pressure range of 87 kPa to 107 kPa, and shall be ±0.5 dB over the temperature range of from $0^{o}C$ to $40^{o}C$ and ±1.0 dB over the temperature range of from $-10^{o}C$ to $50^{o}C$;

(e) if the device is battery powered, means for checking the battery condition shall be included with the device;

(f) the following data shall be provided with the device by the manufacturer,

(i) the nominal sound pressure level produced,

(ii) the nominal frequency at which the device operates,

(iii) the ranges of temperature and atmospheric pressure over which the device is intended to operate, and the applicable overall sound pressure level tolerance for these ranges.

TABLE 102-2

Permissible Tolerances on Microphone Sensitivity
Over an Angle of ± 30°

| Frequency Hz | Permissible Tolerances dB | |
|---|---|---|
| | A* | B** |
| 31.5 - 500 | ±1 | ±1 |
| 1000 | ±1 | ±1 |
| 2000 | ±2 | + 1 - 2 |
| 4000 | ±4 | + 1 - 4 |
| 8000 | ±10 | + 1 - 10 |

* COLUMN A: The microphone is mounted on the sound level meter.

** COLUMN B: The microphone is physically separated from the sound level meter but electrically connected thereto.

TABLE 102-3

Maximum Wind Induced Sound Level Indication Using A-weighting and Slow Response (where available)

| Wind Speed | dBA |
|---|---|
| 15 km/h | 41 |
| 20 km/h | 48 |
| 25 km/h | 53 |

Publication NPC-103

Procedures

1. Scope

This Publication comprises the various measurement procedures to be used in connection with other Publications which provide limits or standards for sound or vibration. Several of the procedures adopted are those of nationally or internationally recognized agencies. Table 103-1 lists the measurement procedures which are included in this Publication.

TABLE 103-1

| NPC-103 Section | Type of Measurement | Procedure |
|---|---|---|
| 3 | Steady or impulsive sound | Ministry |
| 4 | Varying sound | Ministry |
| 5 | Sound and vibration from blasting | Ministry |
| 6 | Powered mobile construction equipment | SAE J88a |
| 7 | Pneumatic equipment | MEMAC |
| 8 | Small engines | SAE J1046 |
| 9 | Trucks with governed diesel engines | CSA Z107.22-M |

2. Technical Definitions

The technical terms used in a procedure shall have the meaning given either in that procedure or in Publication NPC-101 - Technical Definitions.

3. <u>Procedure for Measurement of Steady or Impulsive Sound</u>

(1) (a) <u>Classification</u>

For the purposes of this procedure sounds can conveniently be placed in four mutually exclusive categories as follows:

(i) impulsive sounds, other than Quasi-Steady Impulsive Sounds, such as, but not limited to, the sound from gunshots, certain explosive pest control devices and certain industrial metal working operations (e.g. forging, hammering, punching, stamping, cutting, forming and moulding);

(ii) Quasi-Steady Impulsive Sounds, such as, but not limited to, the sound from pavement breakers, riveting guns, ineffectively muffled internal combustion engines or ineffectively muffled air compressors;

(iii) buzzing sounds, such as, but not limited to, the sounds from positive displacement blowers, chain saws, small combustion engines and concrete finishers;

(iv) all other sounds.

(b) <u>Application</u>

This procedure applies to measurements at a point of reception of:

(i) sound of a type mentioned in category (i) or (ii) of clause (a); and

(ii) sound of a type mentioned in categories (iii) or (iv) of clause (a), which is always higher than the permissible level or which, when the sound is present, does not vary in level over a range of more than 6 dB during the period of observation.

(2) <u>Instrumentation</u>

(a) <u>Sound Level Meter</u>

(i) An Impulse Sound Level Meter shall be used for the measurement of sound in category (i), (ii) or (iii) of clause 3(1) (a).

(ii) A General Purpose Sound Level Meter shall be used for the measurement of sound in category (iv) of clause 3(1) (a). NOTE: An Integrating Sound Level Meter may be used for the measurement of sound in category (iv) of clause 3(1) (a), but the procedure set out in section 4 - Procedure for Measurement of Varying Sound must be used.

(b) <u>Calibrator</u>

An Acoustic Calibrator shall be used.

(c) <u>Windscreen</u>

A windscreen shall be used in all outdoor measurements.

(3) Measurement Location

For sound transmitted solely through air, the measurement location shall be one or more of the following points of reception:

(a) a location out-of-doors where a person may be exposed to the sound; or

(b) the plane of an exterior door or window of a room in which a person may be exposed to the sound, where the door or window is open.

(4) Use of Instrumentation

(a) Battery Check

If the sound level meter is battery powered the condition of the battery shall be checked after the meter has been allowed to warm up and stabilize. The battery condition shall be rechecked at least once per hour during a series of measurements and at the conclusion of such measurements. The meter shall not be used unless the battery condition is confirmed to be within the range recommended by the manufacturer for proper operation.

(b) Calibration

The sound level meter shall be calibrated after the meter has been allowed to warm up and stabilize, at least once per hour during a series of measurements and at the conclusion of such measurements.

(c) Sound Level Meter Settings

Measurements shall be taken using the following response settings:

(i) Impulse Response (dBAI)

The impulse response and A-weighting shall be used for impulsive sound in category (i) of clause 3 (1)(a). An 'impulse hold' facility may be used if available on the meter.

(ii) Slow Response (dBA)

The slow response and A-weighting shall be used for sound in categories (ii), (iii) or (iv) of clause 3 (1)(a).

(d) Instrument Configuration

(i) Reflective Surfaces

The microphone shall be located not less than 1 m above the ground, not less than 1 m from any sound reflective surface except for the purposes of clause 3(3)(b) and not less than arm's length from the body of the person operating the meter. Not more than one person, other than the operator of the meter, shall be within 7 m of the microphone and that person shall be behind the operator of the meter.

For the case of clause 3(3)(b) the microphone shall be in the middle of the aperture located not less than 15 cm from the window frame or door frame.

(ii) Microphone Orientation

The microphone shall be oriented such that the sound to be measured is incident at an angle recommended by the microphone manufacturer for flattest frequency response in a free field.

(e) Measurement - Slow Response

(i) Readings Taken

For sound in categories (ii), (iii) or (iv) of clause 3 (1)(a), a minimum of three observations with a minimum observation time of 15 s each shall be made. The observed average reading for each of the observations shall be noted as well as the minimum and the maximum of the range of sound levels during each observation period. If the difference between any two observed average readings is greater than 3 dB, a minimum of six observations shall be made. For the purpose of adjustments for intermittency the duration of the sound in any one hour shall be noted.

(ii) Readings Reported

The arithmetic mean of the observed average readings shall be reported, rounded to the nearest decibel. Adjustments for intermittence and quality of sound shall be made in accordance with Publication NPC-104 - Sound Level Adjustments, and the result shall be reported. The result is the one hour equivalent sound level ($L_{eq}$) of the sound under study for any one hour period during which the readings were taken pursuant to subclause (i).

(iii) Wide Variation of Sound Levels

If, in making observations pursuant to subclause (i), there is a difference of more than 6 dB between the lowest and highest values of the observed ranges of sound levels, this procedure shall not be used unless the lower limit of each such range is above the maximum permissible level. Instead, the procedure set out in Section 4 - Procedure for Measurement of Varying Sound at a point of reception, shall be used.

(f) Measurement - Impulse Response - Frequent Impulses

(i) Readings Taken

For sound in category (i) of clause 3 (1) (a) not less than 20 impulses shall be measured within a continuous period of 20 minutes and each measurement taken shall be reported.

(ii) Extension of Time

Where a minimum of 20 impulses cannot be measured within a continuous period of 20 minutes pursuant to subclause (i) the time period may be extended to 2 hours if an impulse occurred in each of the four consecutive periods of five minutes each during the initial 20 minute measurement period.

(iii) Level Reported

The Logarithmic Mean Impulse Sound Level ($L_{LM}$) of the 20 or more measurements shall be calculated and reported to the nearest decibel. This Logarithmic Mean Impulse Sound Level is a valid and effective sound level for any one hour period during which readings were taken pursuant to subclauses (i) and (ii).

(g) Measurement - Impulse Response - Single Event Readings Taken and Reported

For impulsive sounds in category (i) of clause 3(1)(a), that occur as single, seemingly independent events not normally measurable using the procedure set out in clause (f) for frequent impulses, each impulse shall be independently measured and each impulse sound level reported to the nearest decibel.

(h) Variation in Calibration

Measurements shall not be reported if the sound level meter calibration has changed more than 0.5 dB from the previous calibration.

(i) Weather Conditions

(i) Wind

Measurements shall not be taken unless the wind-induced sound level is more than 10 dB below the measured levels. Reference should be made to Publication NPC-102 - Instrumentation, particularly Table 102-3.

(ii) Humidity

Measurements shall not be taken if the relative humidity is above the maximum for which the meter specification is guaranteed by the manufacturer (normally 90%).

(iii) Precipitation

Measurements shall not be taken during precipitation.

(iv) Temperature

Measurements shall not be taken when the air temperature is outside the range for which the specification of the instrument is guaranteed by the manufacturer. (Normally, only the lower temperature limit is significant.)

(5) Documentation

The following represents the minimum information which shall be contained in a report of an investigation where the above procedure was used. (Adapted from CSA Z107.2-1973 Methods for the Measurement of Sound Pressure Levels.)

(a) Acoustic Environment

(i) Location and description of sound sources.

(ii) Dimensioned sketch including photographs, if possible, of the location of the sound source and the point of reception, showing all buildings, trees, structures and any other sound reflective surfaces.

(iii) Physical and topographical description of the ground surface.

(iv) Meteorological conditions prevailing at the time of the investigation including approximate local wind speed in km/h, wind direction, air temperature in $^{o}C$, approximate relative humidity and extent of cloud cover.

(b) Instrumentation

All the equipment used for making sound level measurements shall be listed, including:

(i) type, model and serial number of sound level meter;

(ii) type, model and serial number of microphone;

(iii) type, model and serial number of Acoustic Calibrator;

(iv) extension cables and additional amplifier, if used.

(c) Acoustical Data

The measurement details shall be described, including:

(i) the location of the microphone, using a sketch if necessary;

(ii) measurements or readings obtained, preferably listed in tabular form, referencing location on a sketch or map, time periods involved, and relevant data required for making calculations;

(iii) adjustments made for quality of sound or intermittence;

(iv) details of any calculations;

(v) comparison with applicable sound level limits, standards or guidelines.

Publication NPC-105

Stationary Sources

1. Scope

This Publication refers to sound level limits for sound from stationary sources.

2. Technical Definitions

The technical terms used in this Publication are defined in Publication NPC-101 - Technical Definitions.

3. Measurement Standards and Procedures

For the purposes of this Publication all measurements shall be made in accordance with Publication NPC-103 - Procedures.

4. Sound Level Limits - General

(1) For impulsive sound, other than Quasi-Steady Impulsive Sound, from a stationary source, if the sound level is expressed in terms of the Logarithmic Mean Impulse Sound Level ($L_{LM}$), the applicable sound level limit is the one hour equivalent sound level ($L_{eq}$) caused by road traffic as obtained pursuant to Publication NPC-106 - Sound Levels of Road Traffic, for that point of reception and the same time.

(2) For sound from a stationary source, including Quasi-Steady Impulsive Sound but not including other impulsive sound, if the sound level is expressed in terms of the one hour equivalent sound level ($L_{eq}$), the applicable sound level limit is the one hour equivalent sound level ($L_{eq}$) caused by road traffic as obtained pursuant to Publication NPC-106 - Sound Levels of Road Traffic, for that point of reception and the same time.

5. Sound Level Limits - Specific Impulsive Sounds

(1) For impulsive sound, other than Quasi-Steady Impulsive Sound, from a stationary source which is an industrial metal working operation (including but not limited to forging, hammering, punching, stamping, cutting, forming and moulding), if the sound level at a point of reception is expressed in terms of the Logarithmic Mean Impulse Sound Level ($L_{LM}$), the applicable sound level limit for that stationary source if it was in operation before January 1, 1980, is 60 dBAI, and otherwise is 50 dBAI.

(2) For impulsive sound, other than Quasi-Steady Impulsive Sound, from a stationary source which is the discharge of firearms on the premises of a licensed gun club, if the sound level at a point of reception is expressed in terms of the Logarithmic Mean Impulse Sound Level ($L_{LM}$), the applicable sound level limit for that stationary source if it was in operation before January 1, 1980, is 70 dBAI, and otherwise is 50 dBAI.

(3) For impulsive sound, other than Quasi-Steady Impulsive Sound, from a stationary source, characterized by impulses which are so infrequent that they cannot normally be measured using the procedure mentioned in NPC-103 - Procedures, clause 3 (4)(f), if the sound level is expressed in terms of the impulse sound level, the applicable sound level limit is 100 dBAI.

6. Sound Level Limits - Pest Control Devices

(1) For impulsive sound, other than Quasi-Steady Impulsive Sound, from a pest control device employed solely to protect growing crops, if the sound level at a point of reception is expressed in terms of the Logarithmic Mean Impulse Sound Level ($L_{LM}$), the applicable sound level limit is 70 dBAI.

(2) For sound, including Quasi-Steady Impulsive Sound but not including other impulsive sound, from a pest control device employed solely to protect growing crops, if the sound level at a point of reception is expressed in terms of the one hour equivalent sound level ($L_{eq}$), the applicable sound level limit is 60 dBA.

(3) The operation of a pest control device outdoors is prohibited during the hours of darkness.

7. Preemption

(1) For impulsive sound, other than Quasi-Steady Impulsive Sound, if more than one sound level limit in sections 4, 5 and 6 is applicable, the least restrictive applicable sound level limit shall prevail.

(2) For sound, including Quasi-Steady Impulsive Sound but not including other impulsive sound, if more than one sound level limit in sections 4 and 6 is applicable, the less restrictive applicable sound level limit shall prevail.

8. Exclusion

No restrictions apply to a stationary source resulting in an equivalent sound level ($L_{eq}$) of 40 dBA or less at a point of reception.